BOSCH FUEL INJECTION SYSTEM 23C

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GENERAL DESCRIPTION

Fuel Circuit

The Bosch VE Fuel Injection Pump is a high pressure distributor type embodying a governor and timing device.

The system consists of a tank from which the fuel is drawn by a vane pump (integral part of fuel injection pump). Prior to entering the fuel injection pump the fuel passes through a hand primer and a fine mesh filter. The fine mesh filter ensures protection of the pump component parts as the fuel also acts as a lubricating agent.

The vane supply pump supplies a constant fuel quantity per revolution and produces a consistent pressure via the pressure regulating valve. The vane pump pressure regulation and the orifice in the excess flow valve produce a pressure in the pump which is proportional to pump speed. This feature is used to control the automatic injection advance unit. The majority of fuel conveyed flows through the pressure regulating valve and returns to the suction side of the supply pump. The remainder flows through the pump interior to be conveyed into the high pressure chamber or flows through the excess flow valve to the supply tank for cooling and removal of air. Prior to entering the tank the returning fuel passes through a one-way valve and the cold start reservoir.

In the fuel injection pump, high pressure chamber fuel is distributed to the injectors by the pump plunger which is actuated by the drive shaft. The cam plate and rollers in the cam roller ring cause a stroke movement in addition to the rotary movement.

The stroke produces feed at high pressure and the distribution of the injected quantity to the individual injector outlets is made through a metering slit in the distributor pump plunger. The port opening is controlled by the regulating collar opening the spill ports in the pump plunger.

The injector is a pintle type similar to that used on the Ford 2,4 litre diesel with Bosch Plunger Type Fuel Injection Pump. Fuel which leaks through the injector needle spindle/injector nozzle body clearance returns to the tank via the injector leak-off rail.

Mechanical Governor

The mechanical governor incorporated within the upper side of the Bosch VE distributor injection pump, is driven at a speed greater than the injection pump rotational speed by the pump drive shaft via damped gears on the governor weight cage and the main drive shaft. Rotating on the governor spindle is a sliding sleeve and four flyweights. The function of the flyweights is to control the axial sliding sleeve movement by centrifugal force determined by the rotational speed of the drive shaft and opposed by the governor springs.

When the engine is started and the pump has reached a predetermined speed the centrifugal weights push the sliding sleeve forwards on to the starting lever to overcome the weak starting spring. The starting lever actuates a tensioning lever which in turn moves the regulating collar on the pump plunger, thus fuel delivery is regulated.

The amount of pressure the governor sliding sleeve exerts on the tensioning lever via the starting lever and spring is balanced by the governor spring which is adjustable by an external governor control lever.

GENERAL DESCRIPTION (cont'd)

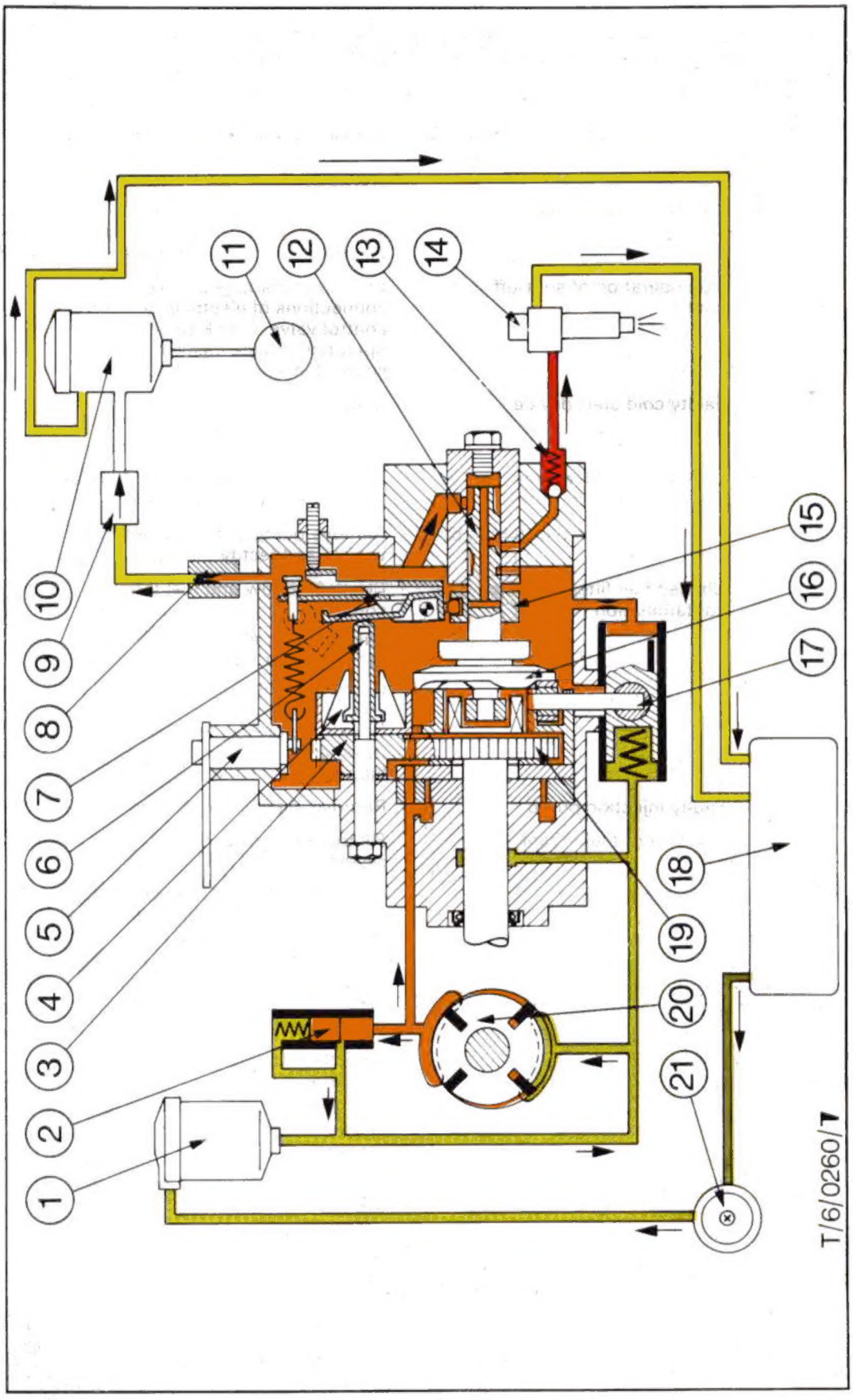


Fig. 1. Fuel Circuit
1. Fine mesh filter
2. Pressure regulating valve
3. Governor
4. Flyweight assembly
5. Control lever
6. Sliding sleeve
7. Lever assembly
8. Excess flow valve
9. One-way valve
10. Cold start reservoir
11. Heater plug
12. Distributor pump plunger
13. Delivery valve
14. Injector
15. Governor control sleeve
16. Camplate
17. Advance piston
18. Fuel tank
19. Governor drive
20. Vane pump
21. Hand prime

FAULT DIAGNOSIS

Introduction

The following fault diagnosis procedure has been devised to give a methodical guide when a fuel fault is not obvious. It is in no way an instruction which must be followed operation by operation. The mechanical condition of the engine, the vehicle history, circumstances and experience together with the following procedure will assist in an accurate diagnosis.

NOTE: Before any part of the fuel system is dismantled the surrounding area must be throughly cleaned.

Trouble Symptoms	Possible Causes	Remedy
Engine will not start or is difficult to start	Insufficient fuel in tank	Fill the fuel tank and bleed the system by filling the primary filter and fuel pump with clean fuel.
	Non operation of shut-off control	Clean and made good electrical connections of electrical shut-off control valve. Check solenoid operation. Check mechanical shut-off lever.
	Faulty cold start device	Check thermostart reservoir for correct supply to the heater plug/s. Check heater plug/s operation.
	Loose pump drive gear or timing slipped	Remove timing belt cover, check and adjust injection pump timing.
	Broken gear pump or timing belt	Remove pump or timing belt from vehicle and rectify.
	Choked fuel filter or fuel oil contamination	Check fuel flow and fuel tank condition.
		The fuel filter element must be changed at the regular intervals recommended.
		Check that the fuel system does not contain water. In sub-zero temperatures it is possible for wax crystals to separate from the fuel and cause a blockage in the fuel system.
	Faulty injection pump	Remove injection pump and rectify.
Engine starts then stops	Insufficient fuel in tank	Fill the fuel tank and bleed the system.
	Fuel starvation	Check that the fuel filter elements are not choked. Ensure that the fuel feed is operating correctly.
		Check all pipe unions and joints in the fuel system for tightness and effective sealing.
		Check that all pipes, including the fuel return pipe, permit unrestricted fuel flow.
		Check that the fuel tank vent is not blocked and there is no air in the system.
	Air starvation	Check and if necessary replace the air cleaner element.
		Check hoses for deterioration, kinks and splits.
		Check that valve clearances are correctly adjusted.

FAULT DIAGNOSIS (cont'd)

Trouble Symptoms	Possible Causes	Remedy
Engine starts then stops	Low idle speed	Check engine condition.
		Check that valve gear (push rods, valve springs, etc.) is operating correctly.
		Check that valve timing is correct.
		Check that all injectors are seated correctly and that a gas-tight seal is effected between the injectors and the cylinder head.
		Check the cylinder head gasket, valve seats, bores, pistons and rings for wear.
		Use a tachometer and set the idle speed (see specifications).
	Faulty stop control lead/lever	Check stop control lead/lever for tightness. Ensure the lead is in good condition and a constant flow is maintained.
Incorrect engine idling and maximum speeds	Air starvation	Check and if necessary replace air cleaner element.
	Fuel starvation	Check that there is no air in the system or water or foreign matter. Check that the fuel filter elements are not choked.
		Check all pipe unions and joints in the fuel system for tightness and effective sealing.
		Check that all pipes permit unrestricted fuel flow, and that, there is no dirt in the system.
	Accelerator linkage	Check accelerator linkage for wear and adjustment. Ensure that the fuel pump control lever is properly secured to the shaft.
	Fuel pump	Check that the control lever is tight on the throttle shaft. Ensure the linkage from the accelerator pedal will permit full throttle opening.
	Faulty injectors	Remove injectors and test.
	Check engine condition	Check that the engine valve gear (push rods, valves, valve springs, etc.) is operating correctly.
		Check for sticking valves, worn valve seats, damaged gaskets, worn bores, worn pistons, worn or sticking rings.
		Ensure injection timing is correct.
	Low maximum speed	Check maximum no-load speed (see specifications).
	Low idle speed	Use a tachometer and set the idle speed (see specifications).

FAULT DIAGNOSIS (cont'd)

Trouble Symptoms	Possible Causes	Remedy
Uneven running misfiring	Check valve clearances	Check that the valve clearances are adjusted correctly. Ensure that the engine valve gear is operating correctly, i.e. no valves are sticking, etc.
	Faulty injectors	Remove injectors, test and rectify as necessary. Check that the injector seatings in the cylinder head are gas-tight.
	Check engine mountings	Check that the engine mountings are secured correctly. Check for vibration being transmitted from some other loose or unbalanced part of the vehicle.
	Air in fuel system	Correct air leak.
	Check engine condition	Remove the radiator cap with engine at idling speed (cold) and check for gas leaks through the coolant. Check for a damaged cylinder head gasket. Check for valve seat damage and valves sticking. Check for worn pistons, sticking rings or worn bores.
Lack of power/poor fuel consumption	Before checking the following possible causes ensure that: 1. The vehicle is not loaded in excess of its plated weight. 2. Tyre pressures are correct for load carried. 3. The clutch is not slipping. 4. The brakes are not binding. 5. The parking brake and drive line are in good working order. 6. The engine reaches its maximum no-load speed. 7. The fuel injection pump has not been tampered with and the seals are unbroken. 8. The density of the exhaust smoke is checked with engine warm and under load. 9. Check the accelerator cable and ensure that the throttle is opening fully.	
	Air starvation	Check and if necessary replace air cleaner element. Check that the engine valve gear is operating correctly.
	Fuel starvation	Check that the fuel filter elements are not choked. Check that the fuel feed is operating correctly. Check all pipe unions and joints in the fuel system for tightness and effective sealing.

FAULT DIAGNOSIS (cont'd)

Trouble Symptons	Possible causes	Remedy
Lack of power/poor fuel consumption (cont'd)	Fuel starvation (cont'd)	Check that all pipes permit unrestricted fuel flow. Check that fuel tank vent is not blocked and that there is no air in the system.
	Engine	Check that the valve clearances are adjusted correctly.
	Exhaust system	Ensure exhaust system is free from internal obstruction.
	Accelerator linkage/cable	Check linkage for excessive wear.
		Check that the engine mounting bolts are tight. Check that when the accelerator pedal is fully depressed the pump control lever contacts the maximum speed screw.
	Stop control	Check that the stop control is operating correctly.
	Fuel injection equipment	Remove and test the injectors. If the fuel injection pump is suspected of being faulty, it must be removed and tested.
	Check engine condition	Remove radiator cap with engine at idling speed (cold) and check for internal gas leaks through coolant.
		Check for damaged cylinder head gasket.
		Check for worn or sticking rings, worn pistons or worn bores.

Excessive exhaust smoke

Note the colour of exhaust smoke, when the engine is on full load, in gear.

(a) White smoke — Denotes incorrect injection timing, low compression or water in the cylinders.

(b) Black smoke — Denotes incomplete combustion due to excess fuel or insufficient air being supplied to the cylinders, or faulty atomisation due to faulty injectors (accompanied by a heavy 'diesel knock').

(c) Blue smoke — Denotes that excessive engine oil is being burned due to faulty valves, valve stems, pistons, rings or bores, or faulty injectors causing a partially unburned fuel condition.

Before checking the following 'Possible Causes' ensure that:

1. The vehicle is not loaded in excess of its plated weight.
2. Tyre pressures are correct for load carried.
3. The brakes are not binding.
4. The clutch is not slipping.
5. The fuel injection pump has not been tampered with and that the seals are unbroken.

FAULT DIAGNOSIS (cont'd)

Trouble Symptoms	Possible Causes	Remedy
	6. The smoke condition only exists when the engine is thoroughly warm.	
	On Nos. 1, 2, 3, and 6 above, excessive smoke will be produced if the engine is subjected to gross over-loading, adverse conditions or incorrect gear use which will lower the engine speed.	
	Air starvation	Check and if necessary replace the air cleaner element.
		Check that valve clearances are correctly adjusted.
		Check that the engine valve gear is operating correctly.
	Fuel injection equipment	Remove injectors and test. Ensure that the specified type of injector is used. Check the injection timing. If the fuel injection pump is suspected of being faulty it must be removed to check the calibration.
Engine will not accelerate correctly	Air starvation	Check and if necessary replace the air cleaner element.
		Check that the engine valve gear is operating correctly and valves are set to the specified clearances.
Engine surge (with throttle in fixed position)	Fuel injectors	Remove injectors and test. Ensure that the specified type of nozzle and injector is used.
	Fuel injection pump linkage	Check accelerator linkage and lever for freedom of movement and excessive wear.
Slow engine die down	Blocked fuel return pipe	Check that the return fuel pipe from the fuel pump to the tank is clear.
	Fuel injection pump linkage	Check accelerator linkage and lever for freedom of movement and excessive wear.

SPECIAL SERVICE TOOLS

NOTE: The following Special Tools are only available through Bosch agents.

Bosch Tool No.	Tool Name
1 685 720 062	Pump adaptor
1 686 430 010 CA	Drive coupling tool
1 688 130 075	Gauge set
1 688 130 139	Measuring tool
KDEP 1086	Control valve remover/replacer
KDEP 1027	Bracing sleeve remover
1 687 233 012	Dial gauge
KDEP 2931	Indicator tool
1 683 458 019	Adaptor
1 688 010 011	Clamping bracket
1 683 391 074	Supply connector
1 683 385 011	Banjo connector
1 683 456 000	Hollow connector
1 683 385 016	Serrated connector
21 016	Timing peg
1 685 720 062	Adaptor flange
KDEP 2963	Mounting yoke
KDEP 1082	Governor shaft nut remover/replacer
KDEP 1080	Screw plug remover/replacer
KDEP 1086	Control valve remover/replacer
KDEP 1032	Base adaptor
1 687 233 012	Dial gauge
KDEP 1084	Register block

SERVICE AND REPAIR OPERATIONS – CONTENT

FUEL SYSTEM		Contain in this publication	Contained in Operation	Unique for Transit
23 142	Fuel system – bleed	X		X
23 412 2	Injection pump – calibrate (injection pump removed)	X		X
23 414	Injection pump – Remove and install	X		X
23 414 8	Injection pump – Overhaul (injection pump removed)	X		X

SERVICE AND REPAIR OPERATIONS

23 142 FUEL SYSTEM – BLEED

Special Service Tools Required: None

1. Raise the hood and secure with the stay.
2. Ensure that all fuel pipe connections are tight and there is sufficient fuel in the fuel tank.
3. Slacken the bleed screw on top of the fuel filter two or three turns.
4. Operate the hand primer (located on the fuel filter) by a 'press and release' motion until air bubbles cease and fuel flows freely from the bleed screw, securely tighten the bleed screw.
5. Switch on the ignition to actuate the stop control solenoid. Move the stop control lever in the start position and slacken the fuel outlet banjo.
   Do not attempt to bleed the injection pump by slackening the hexagon headed bolts situated either side of the pump. This will displace governor components and damage the injection pump.
6. Operate the hand primer until air bubbles cease and fuel flows freely, securely tighten the banjo connection.

   NOTE: Do not attempt to bleed the fuel system by cranking the engine. The injection pump is lubricated by diesel fuel not engine oil. Serious damage may be incurred if the engine is cranked with a dry injection pump.
7. Wipe all surplus diesel oil from the fuel filter and injection pump.
8. Start the engine and check for fuel leaks.
9. Lower the hood and secure.

23 412 2 INJECTION PUMP – CALIBRATE (injection pump removed)

The following procedure details the calibrating procedure using a Bosch Test Stand Fig. 2. When using other test stands consult the test stand manufacturers instructions.

Special Service Tools Required:

Bracing sleeve remover	KDEP 1027
Control valve remover/ replacer	KDEP 1086
Indicator tool	KDEP 2931
Banjo connector	1 683 385 011
Serrated connector	1 683 385 016
Supply connector	1 683 391 074
Hollow connector	1 683 456 000
Adaptor	1 683 458 019
Pump adaptor	1 685 720 062
Drive coupling tool	1 686 430 010CA
Dial gauge	1 687 233 012
Clamping bracket	1 688 010 011
Gauge set	1 688 130 075
Measuring tool	1 688 130 139

1. Fit the pump adaptor flange Special Tool No. 1 685 720 062 to the test stand clamping bracket, Special Tool No. 1 688 010 011 securely tighten the clamp bolts.
2. Fit the drive coupling Special Tool No. 1 686 430 010 CA, to the pump drive shaft. Fit the lockwasher and securely tighten the nut.
3. Engage the drive coupling with the machine drive head. To eliminate play, pull the clamping bracket together with the fuel injection pump away from the drive slightly. Whilst applying this pressure securely tighten the clamping bracket to machine bed bolt.
4. Fit the gauge set to the machine bed (Special Tool No. 1 688 130 075).
5. Fit the machine supply pipe to the pump with connector, Special Tool No. 1 683 391 074.
6. Fit the manometer graduated 0 to 0,6 kgf/cm² to the supply pipe connector.
7. Fit the banjo (Special Tool No. 1 683 385 011) to the 0 to 16 kgf/cm² graduated manometer feed pipe.
8. Fit the manometer feed pipe to the fuel outlet connection. Retain in position with the hollow connector, Special Tool No. 1 683 456 000.
9. Fit the plastic hose to the serrated banjo, Special Tool No. 1 683 385 016.
10. Fit the return hose to the hollow connector. Retain the hose assembly with the pump outlet hollow bolt.

    NOTE: The injection pump must only be tested with the hollow bolt as fitted in production; use of any other bolt will result in incorrect calibration readings.

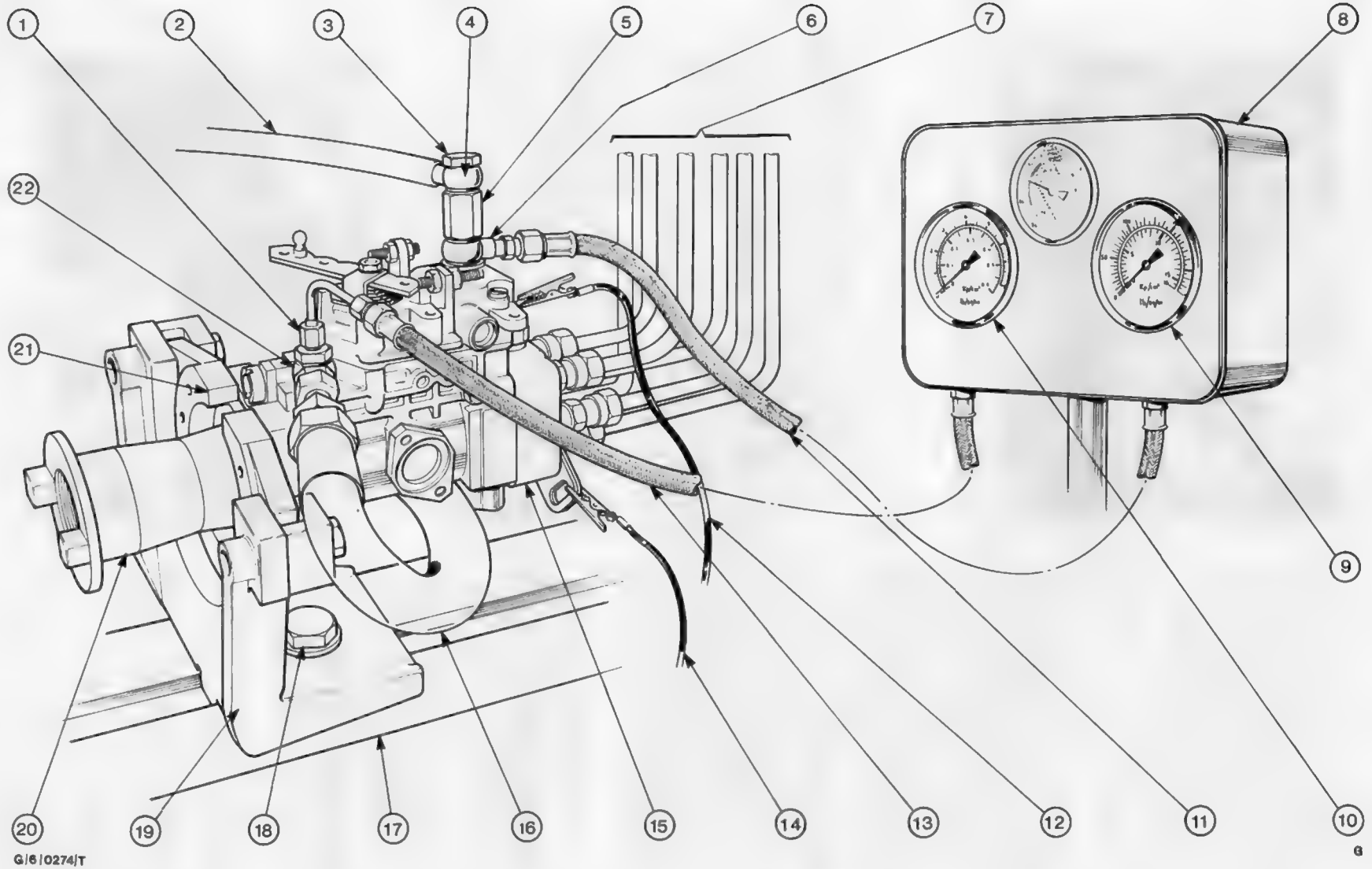


Fig. 2. Bosch Calibration Equipment

1. Supply connector, Special Tool No. 1 683 391 074
2. Plastic hose
3. Pump outlet hollow bolt
4. Serrated connector, Special Tool No. 1 683 385 016
5. Hollow connector, Special Tool No. 1 683 456 000
6. Manometer feed banjo connector, Special Tool No. 1 683 385 011
7. Injection tubes
8. Gauge set
9. Manometer graduated 0 to 16 kgf/cm²
10. Manometer graduated 0 to 0,6 kgf/cm²
11. Manometer supply pipe
12. Solenoid electrical supply
13. Manometer supply pipe
14. Solenoid electrical earth
15. Fuel injection pump
16. Test stand supply pipe
17. Machine bed
18. Clamp bolt
19. Clamping bracket, Special Tool No. 1 688 010 011
20. Drive coupling Special Tool No. 1 686 430 010 CA
21. Adaptor flange, Special Tool No. 1 685 720 062
22. Supply pipe banjo

23 412 2 (cont'd)

11. Fit the fuel injection tubes between the hydraulic head valve holders and the nozzle holder assembly (Note: All nozzles are to be set to 147 bar (147 kgf/cm²) (2091 lbf/in²). It is expedient to mark the fuel injection tubes relative to the letters stamped on the hydraulic head and route the tubes in the same sequence to the nozzle holder assemblies.
12. Remove the two screws and remove the timing device flat cover.
13. Fit the measuring tool Special Tool No. 1 688 130 139 to the pump body, Fig. 3, securely tighten the screws.

IMPORTANT NOTE:

The timing device travel measuring tool embodies a gauge and plunger. The plunger must not be entered in the advance piston end drilling, failure to observe this instruction will result in the bending of the plunger when aligning the tool and pump body screw holes.

14. Check the measuring tool 'Zero'. If correction is required the scale plate must be moved as follows:
    (a) Remove the outer circlip.
    (b) Slide the sight glass from the tool body.
    (c) Loosen the scale plate retaining screws.
    (d) Reposition the scale plate relative to the plunger, securely tighten the retaining screws.
    (e) Carefully refit the sight glass and circlip.
15. Fully retract the accelerator stop screws and disconnect the return spring.

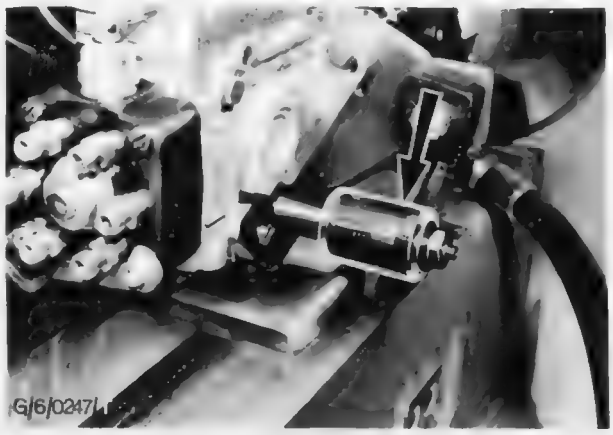


Fig. 3. Measuring Tool Special Tool No. 1 688 130 139

Adjustments

For testing and adjustment purposes the specified test oil is used at a temperature of 313 to 318 °K (40 to 45 °C) (104 to 113 °F) and at a constant feed pressure of 0,2 bar (0,2 kgf/cm²) (2,85 lbf/in²).

Operating the pump to heat the Test Oil

1. Connect a 12 volt supply battery to shut off solenoid. Move the stop control lever to the start position.
2. Pull the accelerator linkage to the maximum fuel position and secure.
3. Set the feed pressure and drive the injection pump for approximately 10 minutes at rated speed.

IMPORTANT NOTE: The fuel injection pump must deliver fluid during this period.

Adjust full load delivery

1. Pull the accelerator linkage to the maximum fuel position and secure.
2. Release the adjustment screw locknut. Remove the screw, remove the spacer if fitted refit the screw.
3. Set the specified full load delivery at the given speed by rotating the adjustment screw, Fig. 4.

If full load delivery will not respond to the adjustment screw the governor may be 'cutting in' prematurely i.e. dimension 'MS' was incorrectly calculated during assembly.

NOTE: Ensure the 'O' ring on the adjustment screw does not emerge from the housing port when specified delivery has been obtained. If this does happen a shorter adjustment screw must be used.

If the adjustment screw is too short i.e. the specified full load delivery cannot be achieved or there is insufficient screw thread to fit the locknut a longer adjustment screw must be used.

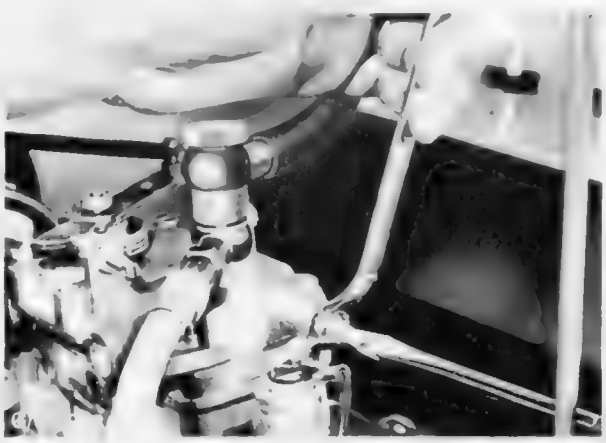


Fig. 4. Adjust full load delivery

Set full load adjustment limits

To prevent unauthorised adjustment a spacer is fitted to the adjustment screw within the housing body.

4. Select a spacer that will allow the correct full load delivery but will only allow the adjustment screw to travel the maximum of $\frac{1}{3}$ of a turn further inwards, Fig. 5.
5. When the specified full load delivery is achieved and the correct spacer is fitted tighten the locknut to specifications.

Adjust the timing device travel and the supply pump pressure

1. Pull the accelerator linkage to the maximum fuel position and secure.
2. Via the centre screw bleed the measuring device, Special Tool No. 1688 130 139.
3. At the specified speed check the supply pump pressure and the timing device (advance piston) travel.

Adjust supply pump pressure

4. When the vent is pressed into the control valve, the supply pump pressure is increased and the timing device is thus advanced. Therefore to increase the supply pump pressure and advance the timing device carefully tap the control valve vent plug into the valve body.
5. If the supply pump pressure must be reduced the control valve vent plug must be drawn back.
6. Using Special Tool No. KDEP 1086 remove the control valve assembly from the pump body.
7. Enter the split nose of Special Tool No. KDEP 1027 into the control valve, Fig. 6.
8. Enter the central rod of Special Tool No. KDEP 1027 into the main tool body. Thus expand the tool nose and engage the valve bracing sleeve.
9. Hold the main tool firmly by the support arm, rotate the upper tool wheel and thus withdraw the bracing sleeve from the control valve.
10. Remove the valve plunger and spring.
11. Using a suitable mandrel press the control valve vent plug towards the valve upper face.
12. Replace the spring and valve plunger.
13. Using a suitable mandrel press a new bracing sleeve into the control valve body. When fitted the bracing sleeve must be flush with the end of the valve. The mandrel must insert the bracing sleeve without damage to either the sleeve or valve body i.e. no chips or burrs.
14. Fit two new 'O' rings to the valve body.

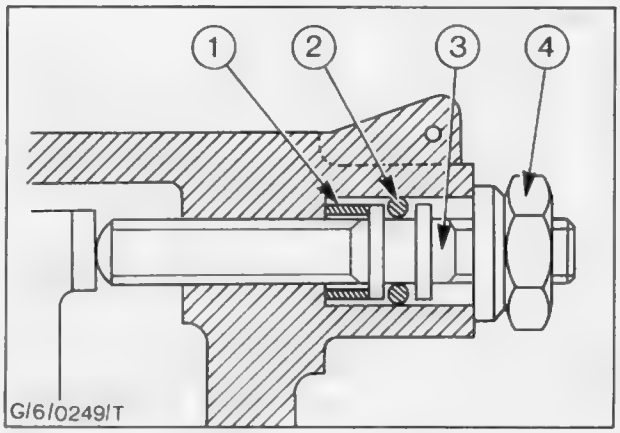


Fig. 5. Full load adjustment
1. Spacer
2. 'O' ring
3. Adjustment Screw
4. Lock nut

15. Using Special Tool No. KDEP 1086 fit the control valve to the pump housing, tighten to specifications.
16. The supply pump pressure may now be adjusted as detailed in operation number 4.

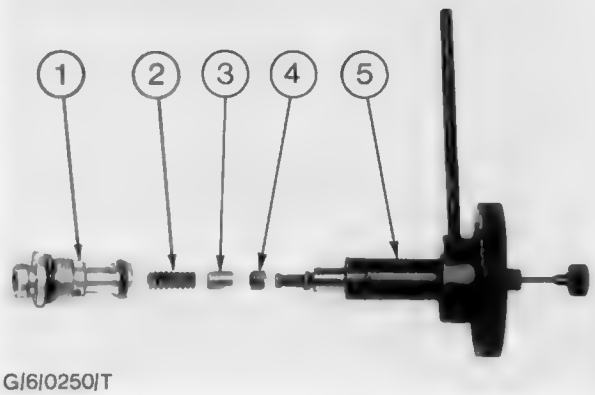


Fig. 6. Supply pump pressure control valve
1. Control valve
2. Valve spring
3. Valve plunger
4. Bracing sleeve
5. Special Tool no. KDEP 1027

23 412 2 (cont'd)

Adjust timing device travel

17. If the specified timing device travel is not attained when the supply pump pressure tolerance is utilized it can be changed by means of plain washers used to vary the spring preload. See specifications and 23 414 8 Fuel Injection Pump Overhaul (Injection Pump Removed). Operations 70 to 74.

18. After adjusting the timing device travel and the supply pump pressure the full load delivery must be rechecked.

Adjust low idle setting

1. Push the accelerator lever up against the idle speed adjustment screw, Fig. 7.

2. At the given speed set the specified idle delivery using the idle adjustment screw.

3. Measure the distance 'A' (see specifications). If the measured distance is not as specified the accelerator lever must be removed and rotated relative to the spindle.

4. Ensure the return spring, retaining bracket, lockwasher and nut are correctly repositioned. Tighten the nut to specifications.

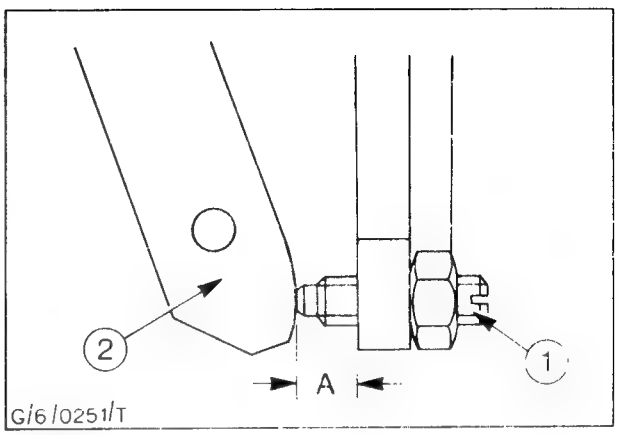


Fig. 7. Adjust low idle setting
1. Idle adjustment screw 2. Accelerator lever

Measure excess fuel for starting

1. At the specified speed check the fuel delivery. Note the speed at which the fuel delivery reading is taken must be approached from a lower speed i.e. do not exceed and then lower the r.p.m. to attain the specified speed.

2. If the excess fuel for starting value is not as specified, the dimension 'MS' (starting fuel) has been incorrectly calculated during assembly.

Adjust maximum speed setting

1. Push the accelerator linkage against the speed adjustment screw, Fig. 8.

2. Turn the speed adjustment screw inward until the specified amount of fuel is delivered at the given speed.

3. Tighten the adjustment screw locknut to specifications.

4. Measure dimension 'B' (adjustment distance) between the idle adjustment screw and the speed adjustment screw. Note: the accelerator linkage must be held against the idle adjustment screw.

5. If the measured dimension is not to specifications the wrong type of governor spring may have been fitted.

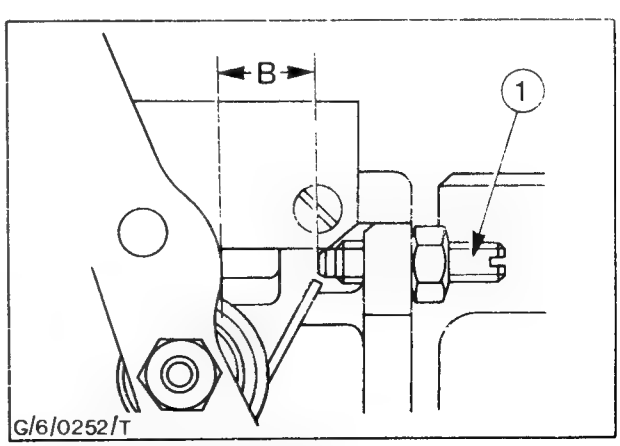


Fig. 8. Adjust maximum speed setting
1. Adjustment screw

Adjust timing, Fig. 9.

This procedure requires the pump flange to be fitted. The pump must therefore be temporarily removed from the test stand and held in a 'Soft Jaw' bench vice.

1. Fit the dial gauge Special Tool No. 1 687 233 012 to the indicator tool Special Tool No. KDEP 2931, securely tighten the allen screw clamp.
2. Fit the adaptor Special Tool No. 1 683 458 019 to the indicator tool, ensure the copper washer is correctly positioned, and securely tighten.
3. Push the adaptor plunger and ensure a dial indicator travel of 2 mm plus.
4. Remove the screw and copper washer from the central screw plug.
5. Fit the special tool assembly to the central screw plug. When fully tightened ensure the adaptor plunger has registered on the injection pump cam i.e. the dial gauge pointer has moved.

   NOTE: the dial indicator movement at this stage should not exceed approximately 0,05 mm. This dimension ensures a correct zero on the pump cam but allows sufficient unused movement for the cam lift readings.
6. Via the drive shaft nut rotate the pump in a clockwise direction (i.e. the direction of rotation in service).
7. Zero the dial indicator on the cam dwell prior to the plunger stroke for Number 1 cylinder i.e. the timing marks will be close to one another.
8. Continue to rotate the pump drive shaft and stop at the specified dial indicator reading.
9. Retain the pump in this position, loosen the adjustable timing marks align both marks and securely tighten the retaining screws.

Pre-stroke, Fig. 9.

10. Fit the spill pipe to the special tool assembly.
11. Via the drive shaft nut rotate the pump in a clockwise direction (i.e. the direction of rotation in Service).
12. Apply a test machine feed pressure of 20KN/m².
13. The flow from the spill pipe should 'cut off' at specified camlift, read from the dial indicator. An incorrect 'cut off' figure is corrected by changing the shim beneath the pump plunger i.e. dimension K was incorrectly calculated during assembly. If dimension K is checked and a revised shim is fitted beneath the plunger, dimension KF must also be checked as the two dimensions are inter related.
14. Remove the special tool.
15. Fit the screw and copper washer to the central screw plug tighten to specifications.

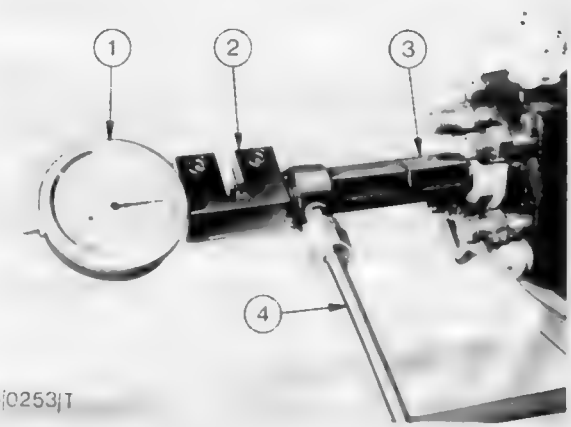


Fig. 9. Timing and pre-stroke adjustment
1. Dial guage Special Tool No. 1687 233 012
2. Indicator tool Special Tool No. KDEP 2931
3. Adaptor Special Tool No. 1683 458 019
4. Spill pipe

Testing

Test timing device travel and supply pump pressure

1. Push the accelerator lever up against the adjustment screw (maximum fuel position).
2. At the specified speeds check the supply pump pressures and the timing device travel.
3. Incorrect values must be rectified as previously detailed in **Adjust supply pump pressure** and **Adjust timing device travel.**

NOTE: Defects in the supply pump or in the valve affect both the supply pump pressure and the timing-device travel. Defects in the timing device (i.e. the wrong type of spring) affect the timing device travel only.

Test zero delivery (Stop)
Electric solenoid type

1. Hold the accelerator lever in the maximum position.
2. Run the pump at 100 rpm, for **no longer than 30 seconds**, with no voltage applied to the stop solenoid. The pump should deliver no fuel to the injectors.
3. Connect a variable D.C. supply to the solenoid; positive supply to the solenoid spade terminal, negative supply to earth.
4. Run the pump at 100 rpm, for **no longer than 30 seconds**, and steadily increase the solenoid supply voltage. Fuel delivery must start before a supply voltage of 8 volts.
5. Reduce the supply voltage to 6 volts. Measure the fuel delivery over 100 shots, see specifications.
6. Increase speed to 1800 rpm measure the fuel delivery over 200 shots, see specifications.
7. Terminate electrical supply, fuel delivery should cease within 2 seconds.

Mechanical type

1. Hold the accelerator lever in the maximum position.
2. Run the pump at 100 rpm with stop control lever in the stop position. The pump should deliver no fuel to the injectors.
3. Allow the stop control lever to move towards the run position under the influence of the spiral return spring, i.e. do not assist the lever movement.
   Fuel delivery should start at the injectors within 2 seconds.
4. Measure the fuel delivery over 100 shots, see specification.
5. Increase speed to 1800 rpm and measure the fuel delivery over 100 shots, see specification.
6. Pull the control lever to the stop position, fuel delivery should cease within 2 seconds.

MEASURE THE OVERFLOW QUANTITY

1. Push the accelerator lever up against the adjustment screw (maximum fuel position).
2. Measure the overflow quantity of test oil returned using a suitable measuring glass, at the specified speed. Incorrect values must be rectified by checking (a) **Supply Pump Pressure,** and (b) that the outlet hollow bolt orifice is unobstructed.

NOTE: Outlet hollow bolts are matched to each individual fuel injection pump. The fitment of an incorrect bolt would therefore lead to incorrect pump operation.

Testing fuel delivery and breakaway characteristic

1. Measure the amounts of fuel delivered at the given speeds with the accelerator lever in the specified position.

   Incorrect values must be rectified by checking the **full load delivery.**
2. Remove the connections and thus disconnect the fuel injection pump from the manometers.
3. Remove the fuel injection tubes from the hydraulic head.
4. Remove the measuring tool from the timing device fit the cover and tighten the securing screws to specification.
5. Remove the pump/adaptor flange from the test stand.
6. Remove the pump from the adaptor.
7. Fit the pump flange, securely tighten the retaining bolts.
8. Fit the drive pulley to the pump drive shaft. Fit the lockwasher and nut, tighten the nut to specifications.

23 414 INJECTION PUMP – REMOVE AND INSTALL

Special Service Tools Required:

Timing peg 21 016

To remove the timing belt cover

1. Raise the hood and secure with the stay.
2. Drain the cooling system.
3. Disconnect the battery.
4. Remove the air cleaner assembly.
5. Disconnect the top hose at the radiator location.
6. Disconnect the expansion tank to hose mounting bracket, remove the hose and bracket assembly.
7. Fit the pump flange, securely tighten the retaining bolts.
8. Remove the radiator mounting bolts and rubber mountings, remove the radiator.
9. Slacken the vacuum pump drive belt jockey pulley and remove the drive belt.
10. Slacken the alternator mounting bolts and remove the alternator drive belt.
11. Remove the four fan retaining bolts and remove the fan, spacer and pulley.
12. Remove the screws securing the timing belt cover to the engine and remove the timing belt cover.

To remove the injection pump

13. Disconnect the throttle cable from the injection pump.
14. Disconnect the stop control lead/cable.
15. Remove the injection pump fuel feed and return pipes, fit dust caps. Retain the outlet banjo securing bolt in the injection pump protected by a suitable sleeve.
16. Remove the injector delivery pipes from the injectors and injection pump, fit dust caps.
17. Turn the engine to T.D.C. with No. 1 piston on compression stroke and locate the timing peg (Special Tool No. 21 016) through the hole in the camshaft gear and the engine front cover, Fig. 10.
18. Slacken the injection pump drive gear retaining bolts.
19. Slacken the timing belt tensioner retaining bolts, return the tensioner to the unloaded position, and securely tighten the tensioner retaining bolts, remove the timing belt from the injection pump drive gear.
20. Remove the previously slackened injection pump drive gear bolts, remove the plate and drive gear from the injection pump.
21. Remove the two bolts which secure the pump rear support bracket to the engine block, Fig. 11.

Fig. 10 Timing peg Special Tool No. 21 016

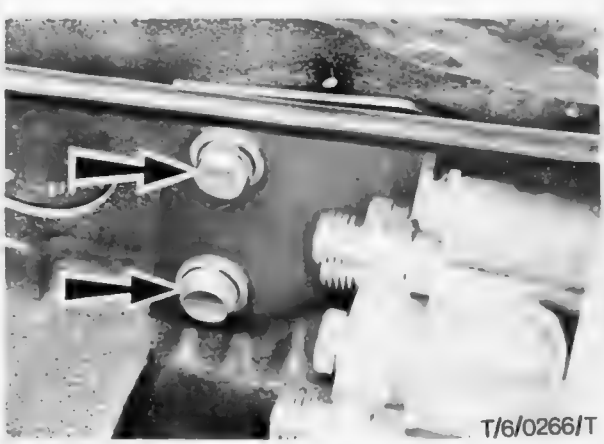


Fig. 11. Pump rear support bracket retaining bolts

23 414 (cont'd)

22. Slacken the engine block bracket to pump rear support bracket retaining nut.
23. Remove the remaining nuts and bolts and the throttle cable bracket retaining bolt from the pump mounting plate, remove the pump and mounting plate assembly from the vehicle, Fig. 12.
24. Remove the support bracket assembly from the rear of the injection pump.

To install the injection pump

25. Clean all mating surfaces.
26. Fit the support bracket to the rear of the injection pump and secure but do not tighten the retaining nut.
27. Position the injection pump in the engine front cover and secure with the two nuts and bolts.
28. Replace the accelerator cable bracket and secure with the retaining bolts.
29. Fit the two lower pump mounting plate bolts.
30. Securely tighten the pump mounting plate retaining nuts and bolts.
31. Fit the pump rear support bracket to the engine block and secure with the two retaining bolts.
32. Securely tighten the engine bracket to pump rear support bracket nut.
33. Remove the dust caps, replace the injector delivery, fuel feed and return pipes, securely tighten, Fig. 13.

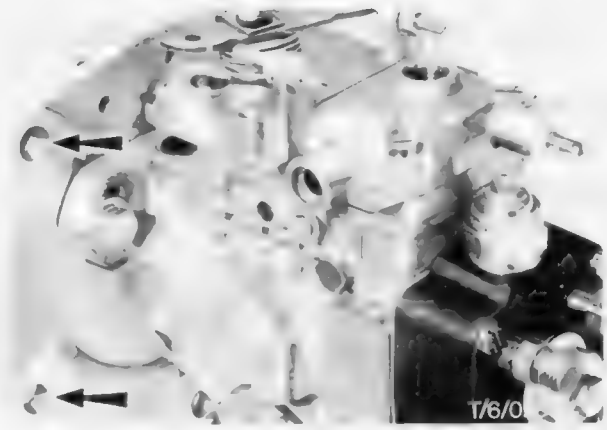


Fig. 12. Pump and mounting plate, both removed from front cover

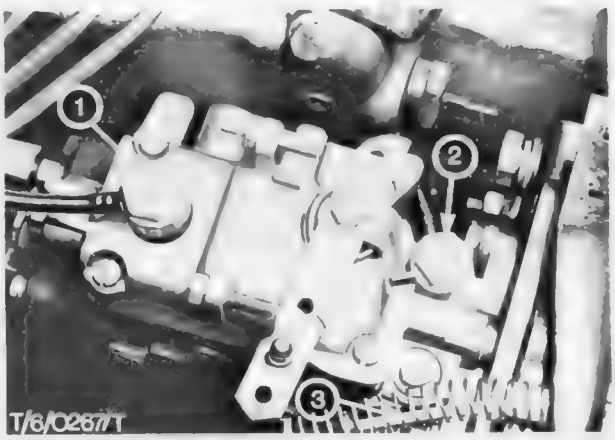


Fig. 13. Pump installation
1. Fuel return
2. Fuel feed
3. Accelerator cable

34. Assemble the drive gear ('FORD' stamped letter outermost) and plate to the injection pump, replace the retaining bolts but do not tighten. The bolt holes in the pump drive flange are arranged so the drive gear can only be located in one position.
35. Turn the injection pump drive gear until the timing pointer coincides with the TDC mark on the drive gear.
36. Ensure the timing peg (Special Tool No. 21 016) is located in the camshaft/engine front cover position and the crankshaft timing marks are aligned, Fig. 14.

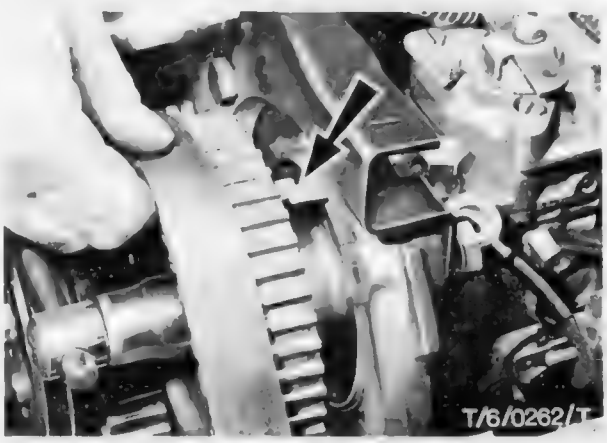


Fig. 14. Timing marks

37. Assemble the timing belt on the injection pump drive gear ensuring the timing marks do not move and the timing belt serrations are aligned with the gear teeth. If necessary move the drive gear in the pump using the slotted holes in the gear to allow the belt to mesh. It will be necessary to hold the injection pump gear in the TDC position whilst replacing the drive belt.
38. Securely tighten the drive gear retaining nuts.
39. Slacken the timing belt tensioner retaining bolts, actuate the tensioner mechanism by sharply depressing the longest span of the timing belt.
40. Securely tighten the tensioner retaining bolts and remove the timing peg (Special Tool No. 21 016) from the camshaft gear.
41. Rotate the crankshaft two revolutions in the normal rotational direction and recheck the injection pump timing, adjust if necessary by slackening the pump drive gear retaining nuts and moving the pump within the slotted holes in the drive gear. Securely tighten the gear retaining nuts.
42. Replace the stop control lead/cable and connect the throttle cable.
43. Bleed the fuel system as detailed in Operation No. 23 142.

To replace the timing belt cover

44. Replace the timing belt cover; fit and securely tighten the retaining screws.
45. Replace the fan pulley, spacer and fan assembly, securely tighten the four retaining bolts.
46. Replace the alternator drive belt and adjust via the alternator to the specified belt deflection measurement, securely tighten the alternator mounting bolts
47. Replace the vacuum pump drive belt and adjust via the jockey pulley to the specified belt deflection measurement, securely tighten the jockey pulley retaining nuts.
48. Replace the four radiator mounting rubbers and radiator, securely tighten the mounting bolts.
49. Fit the air return hose to the expansion tank, securely tighten the hose clip.
50. Replace the hose and bracket assembly to the expansion tank, securely tighten the hose clips and bracket retaining bolt.
51. Fit and securely tighten the top hose at the radiator location.
52. Replace the air cleaner assembly.
53. Refill the cooling system.
54. Connect the battery, start the engine, check for oil, fuel, and water leaks.
55. Lower the hood and secure.

23 414 8 FUEL INJECTION PUMP – OVERHAUL (Injection pump removed)

Special Service Tools Required:

Base adaptor	KDEP 1032
Screw plug remover/replacer	KDEP 1080
Governor shaft nut remover/ replacer	KDEP 1082
Register block	KDEP 1084
Control valve remover/replacer	KDEP 1086
Mounting yoke	KDEP 2963
Adaptor flange	1 685 720 062
Dial gauge	1 687 233 012

To Dismantle

1. Remove the drive shaft nut and washer.
2. Using a suitable puller remove the drive pulley.

   NOTE: When removing the drive pulley under no circumstances 'strike' the drive shaft as serious pump damage will result.
3. Remove the three bolts and remove the pump flange.
4. Fit the pump to the adaptor flange (Special Tool No. 1 685 720 062).
5. Fit the pump/adaptor to the mounting yoke (Special Tool No. KDEP 2963). Fit the yoke to support clamp or a suitable bench vice, Fig. 15.
6. Remove the screws and carefully lift off the housing cover, Fig. 16.
7. Unhook the **governor** spring from the retaining pin.
8. Remove the accelerator linkage centre nut and the spring retaining bracket.
9. Mark the accelerator linkage relative to the spindle, remove the linkage and return spring.
10. Remove the spindle and interior linkage from the housing cover.

Remove mechanical shut-off (if fitted)

11. Unhook mechanical shut-off return spring.
12. Remove shut-off lever retaining nut and lockwasher.
13. Remove outer lever, shim and seal.
14. Push the shaft into the housing cover and thus remove the shaft and inner linkage from the cover.

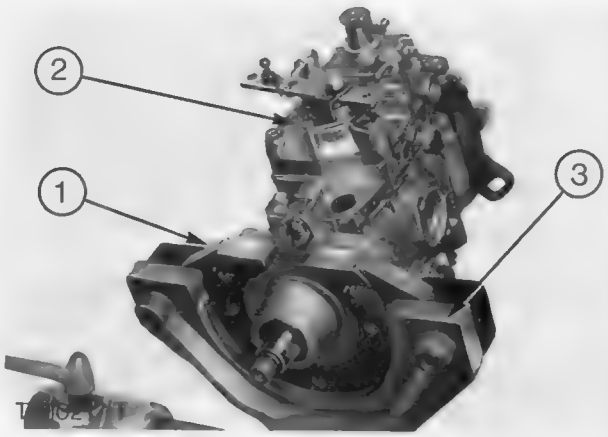


Fig. 15. Mounting the fuel pump
1. Adaptor Special Tool No. 1 685 720 062
2. Fuel injection pump
3. Mounting yoke Special Tool No. KDEP 2963

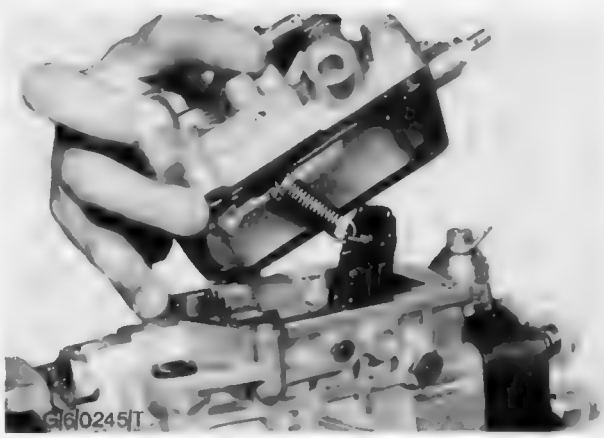


Fig. 16. Lift off the housing cover

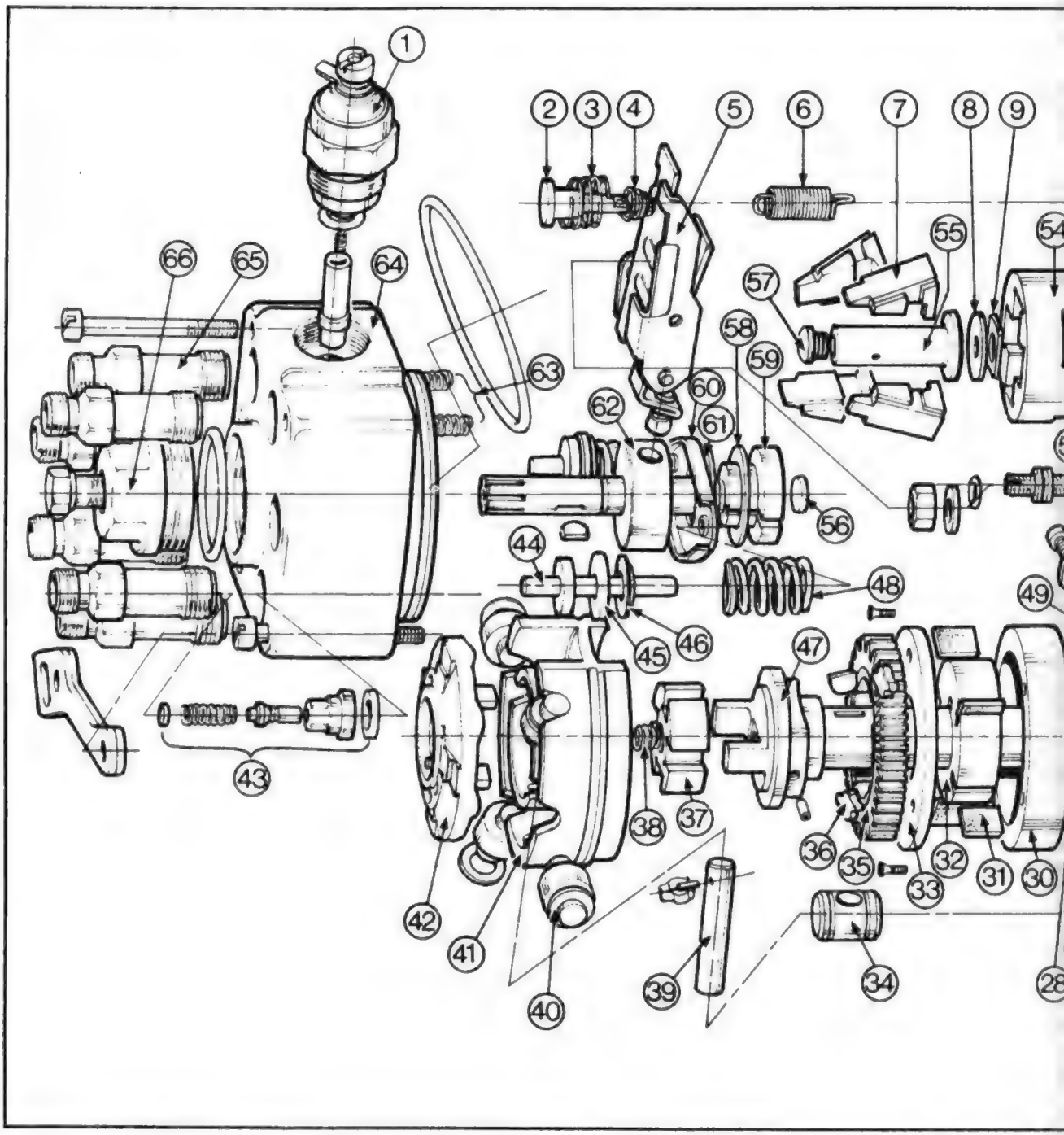
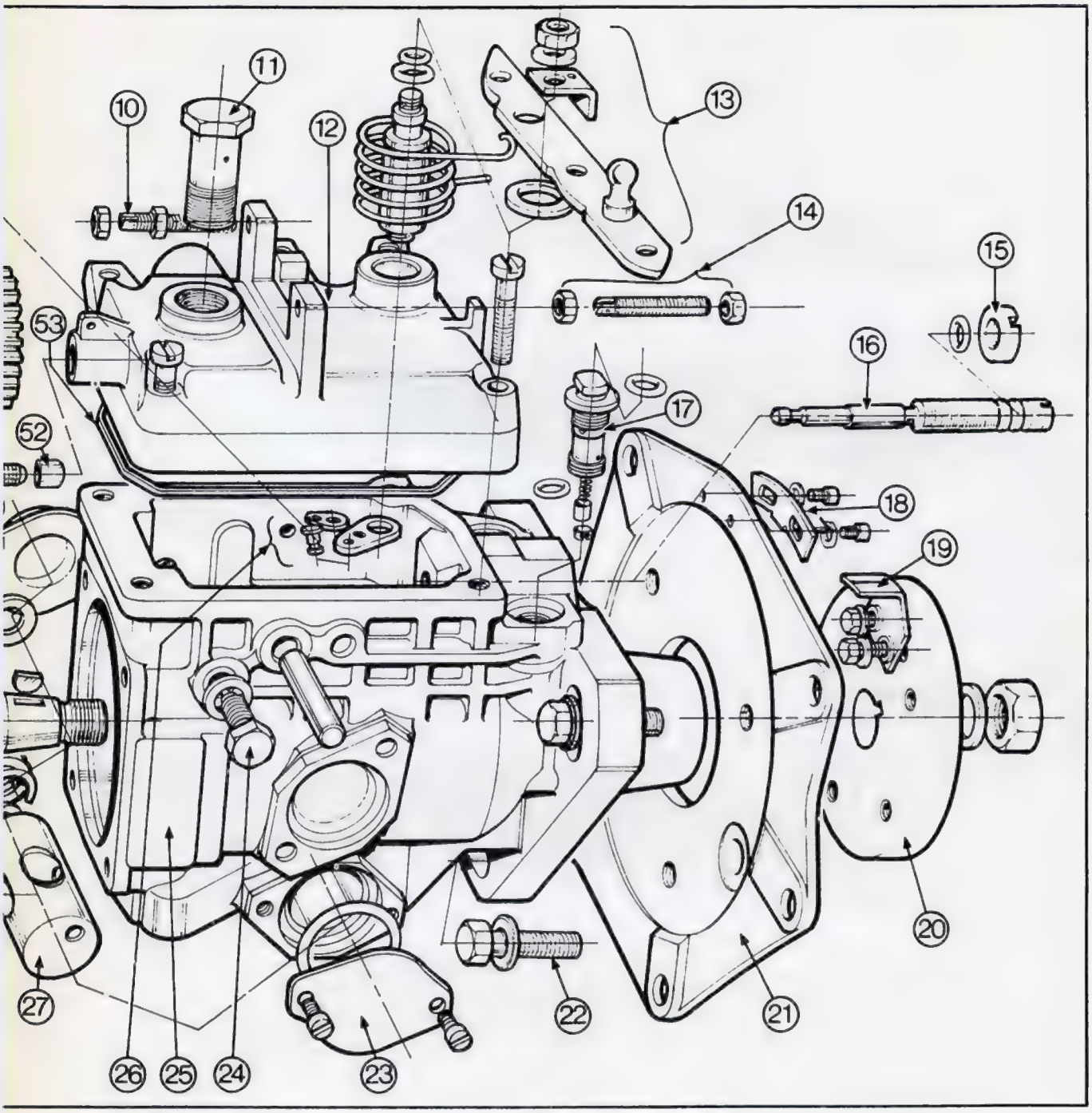


Fig. 17 Fuel Injection Pump

1. Solenoid
2. Retaining pin
3. Outer compression spring
4. Inner compression spring
5. Control lever assembly
6. Governor spring
7. Flyweight
8. Shim
9. Shim plate
10. Speed adjustment screw
11. Pump outlet hollow bolt
12. Housing cover
13. Accelerator lever assembly
14. Adjustment screw and locknuts
15. Governor shaft slotted nut
16. Governor shaft
17. Pressure control valve
18. Adjustable timing mark
19. Fixed timing mark
20. Drive pulley
21. Pump flange
22. Retaining bolt
23. Timing device flat cover
24. Control lever pivot bolt
25. Pump body
26. Accelerator interior linkage
27. Advance piston
28. Piston compression spring
29. Shim
30. Vane pump eccentric ring
31. Vane
32. Vane pump impellor
33. Vane pump retaining plate



34	Cross piece	45.	Shim	56.	Plunger base shim
35	Drive gear	46.	Upper spring plate	57.	Sliding sleeve nipple
36	Rubber buffer	47.	Drive shaft	58.	Thrust washer
37	Drive coupling	48	Plunger spring	59.	Pump plunger
38	Camplate compression spring	49.	Shim	60.	Lower spring plate
39	Connecting shaft	50.	Recess cover	61.	Shim
40	Roller assembly	51.	Full load delivery adjustment screw	62.	Governor control sleeve
41	Cam roller ring	52.	Spacer	63.	Compression springs
42	Camplate	53.	Housing cover seal ring	64.	Hydraulic head
43.	Valve assembly	54.	Governor gauge	65.	Valve holder
44.	Spring carrier	55.	Sliding sleeve	66.	Screw plug

All models

15. Remove the retaining pin and helical compression springs from the tensioning lever, Fig. 18.
16. Position the pump vertically and using the socket part only of Special Tool No. KDEP 1082 slacken the governor shaft slotted nut.

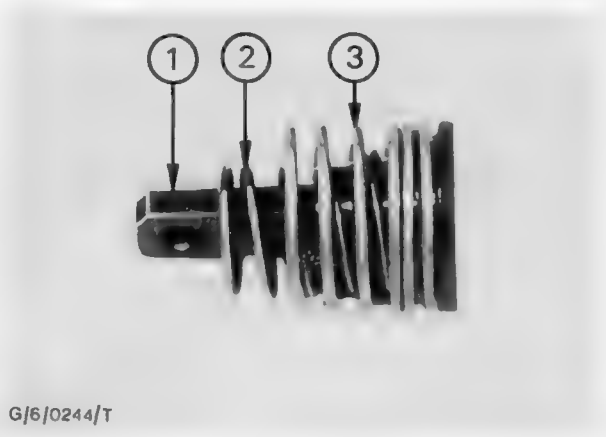


Fig. 18. 1. Retaining Pin
2. Inner compression spring
3. Outer compression spring

17. Unscrew the governor shaft, lift out the flyweight assembly, shims and shim plate, Fig. 19.
18. Remove the flyweights, spacer and sliding sleeve from the governor cage.
19. Using Special Tool No. KDEP 1080 remove the screw plug and 'O' ring.
20. Note the relative positions i.e. A, B, C, D and remove the delivery valve holders, shims, springs and the two valve components from the hydraulic head.
21. Remove the copper washers from the hydraulic head.
22. Remove the fuel shut-off solenoid if fitted.

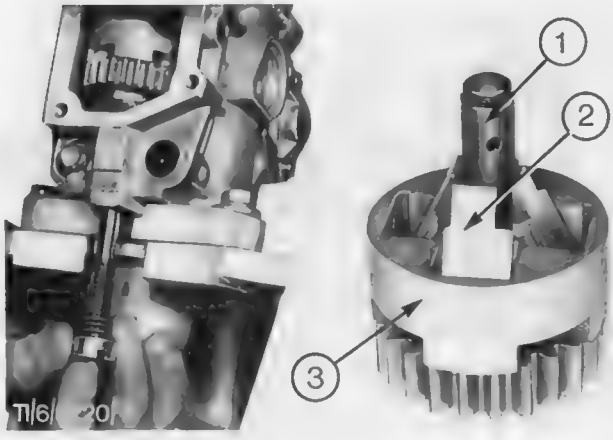


Fig. 19. Unscrew the governor shaft
1. Sliding sleeve
2. Flyweight
3. Governor cage

23. Remove the screws and remove the hydraulic head. During this operation care must be taken as once the hydraulic head is removed the compression springs, plunger springs, guides, shims, upper and lower spring plates are no longer positively retained, Fig. 20.
24. Lift out the pump plunger, governor control sleeve, springs and spring carrier assemblies.

    NOTE: A shim is located beneath the plunger assembly.
25. Remove the spring and spring retainers.
26. Remove the shims and upper spring plates from the spring retainers.
27. Remove the governor central sleeve from the pump plunger.

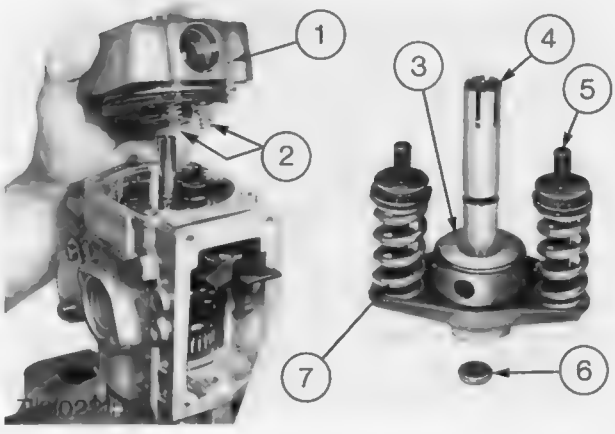


Fig. 20. Remove hydraulic head and pump plunger assembly
1. Hydraulic head
2. Compression springs
3. Governor control sleeve
4. Pump plunger
5. Spring carrier
6. Plunger base shim
7. Plunger spring

23 414 8 (cont'd)

28. Remove the pump plunger thrust washer and shim from the lower spring plate, Fig. 21.
29. Remove the two control lever assembly pivot bolts and washers from the pump body.
30. Remove the control lever assembly consisting of start lever, tensioning lever and correction lever from pump interior.

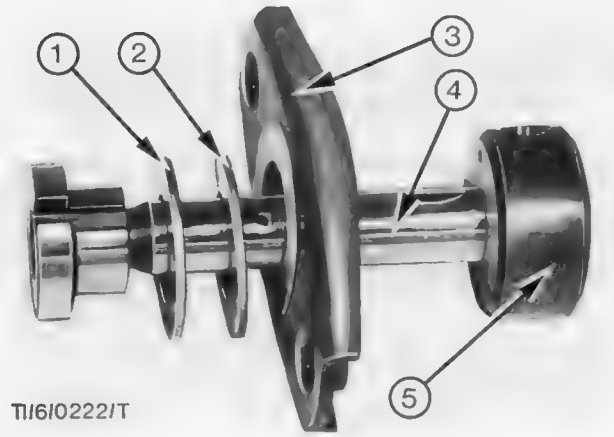


Fig. 21. Pump plunger assembly
1. Thrust washer
2. Shim
3. Lower spring plate
4. Pump plunger
5. Governor control sleeve

31. Remove the cam plate.
32. Remove the compression spring and drive coupling, Fig. 22.
33. Remove the two screws and remove the timing device flat cover (right hand side of pump body when viewed from the hydraulic head to pump body mating face). Discard the 'O' ring.
34. Remove the two screws and remove the timing device 'recess' cover. Remove the shim and compression spring. Discard the 'O' ring.
35. Remove the inner shim from the advance piston.

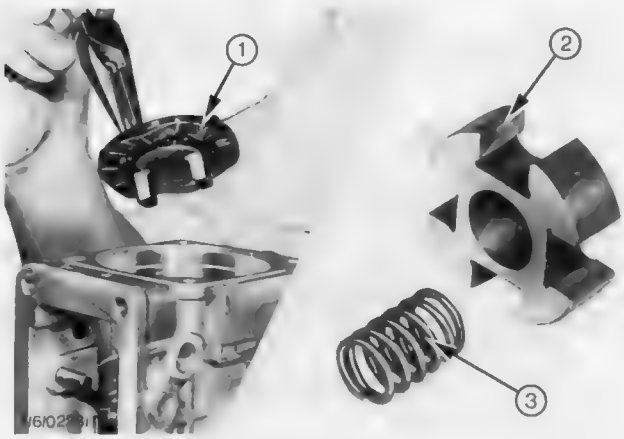


Fig. 22. 1. Camplate
2. Drive coupling
3. Compression spring

36. Remove the spring clip and pin from the advance piston to roller ring connecting shaft, Fig. 23.
37. Slide the connecting shaft into the roller ring i.e. disengage from the advance piston.
38. Lift the cam roller ring from the pump body.
Caution. Each roller is machine matched to the inner and outer ring to ensure rotational flatness. Therefore if a roller is displaced it must be refitted to the correct (original) roller seats in the inner and outer ring.

NOTE: when removed the cam roller ring must be protected by a suitable cover to prevent both dirt ingress and roller displacement.

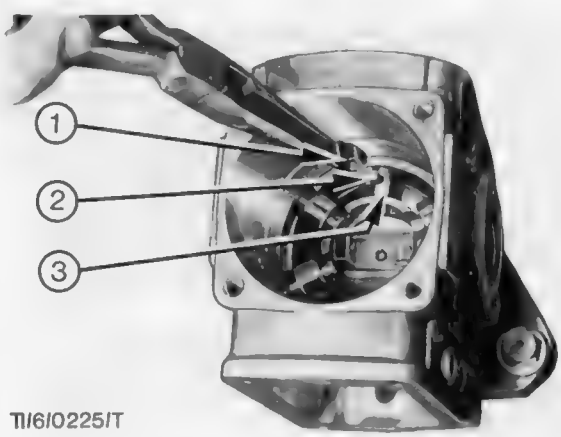


Fig. 23. 1. Spring clip
2. Pin
3. Connecting shaft

39. Remove the advance piston and cross piece, Fig. 24.

Fig. 24. 1. Advance piston 2. Cross piece

40. Remove the drive shaft assembly. Remove the thrust washer, gear and rubber buffers, Fig. 25.

41. Remove the two screws and thus remove the vane pump retaining plate.

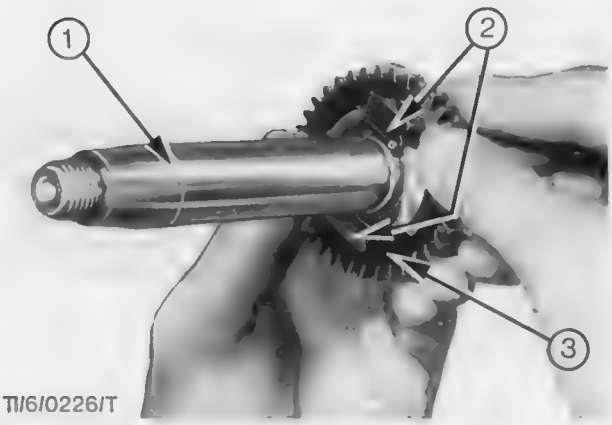


Fig. 25. Driveshaft assembly
1. Drive shaft
2. Rubber buffers
3. Drive gear

42. Position a suitable circular mandrel against the vane pump. The mandrel diameter must be large enough to cover the outer eccentric ring.

43. Invert the pump, gently tap the pump body with a rubber hammer. Thus remove the vane pump assembly supported upon the mandrel.

44. Using Special Tool No. KDEP 1086 remove the pressure control valve, Fig. 27.

45. Carefully remove the drive shaft oil seal from the pump body.

46. (a) Throughly clean all parts in clean diesel fuel oil or fuel oil substitute.

(b) Discard all 'O' rings.

(c) Replace all worn and damaged parts.

(d) The control edges of the pump plunger must be sharp and the contact surfaces must not exhibit any running cracks/ tracks.

(e) The following assemblies are to be replaced as units.

Pump plunger and governor control sleeve; Cam roller ring and rollers; vane pump impeller, vanes and eccentric ring.

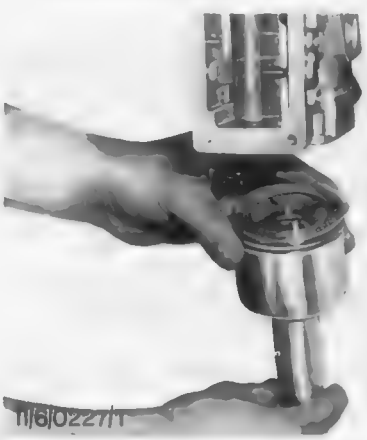


Fig. 26. Remove the vane pump

23 414 8 (cont'd)

To Reassemble

47. When assembling fuel pump components all parts including 'O' rings must be lubricated with fuel oil substitute.

    NOTE: The working surface and area must be clean when assembling the pump parts. The ingress of foreign particles will result in fuel pump/system failure.

48. Position the vane pump retaining plate, impeller vanes and eccentric ring on the removal mandrel as follows:

49. Place the retaining plate on the mandrel.

50. The two holes opposite each other in the eccentric ring are not equally spaced to the inner edge of the ring. The hole furthest from the inner edge must be positioned on the right when looking onto the assembled mandrel and retaining plate, Fig. 28.

51. Fit the vane pump impeller into the eccentric ring.

52. Fit the vanes to the impeller with convex face ends contacting the eccentric ring.

53. Introduce the assembled vane pump parts into the pump body, ensure the third eccentric ring hole is positioned towards the housing cover.

54. Rotate the pump housing through 180°, remove the mandrel.

55. Align the retaining plate holes with those machined in the eccentric ring.

56. Ensure the third hole (see sub operation 53) remains positioned towards the housing cover.

57. Fit and tighten the countersunk-head retaining screws to specifications.

58. Ensure the vane pump is free to rotate beneath the retaining plate.

59. If the spring pin (roll pin) has been removed a new pin must be pressed into the drive shaft to the dimension specified, Fig. 29. Remove any loose metal.

60. Push the gear wheel onto the drive shaft, the gear recess must face the drive coupling.

61. Press two new rubber buffers into the gear recesses.

62. Using a suitable grease fit the thrust washer and key to the drive shaft.

63. Using a suitable mandrel fit a new drive shaft oil seal to pump body.

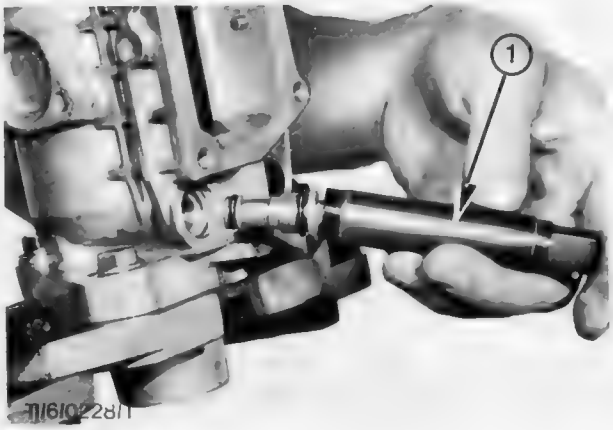


Fig. 27. Remove the pressure control valve
1. Special tool no KDEP 1086

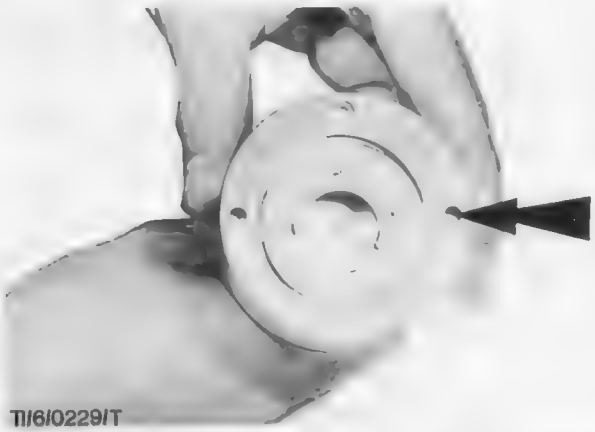


Fig. 28. Hole furthest from inner edge positioned on right when viewed from above

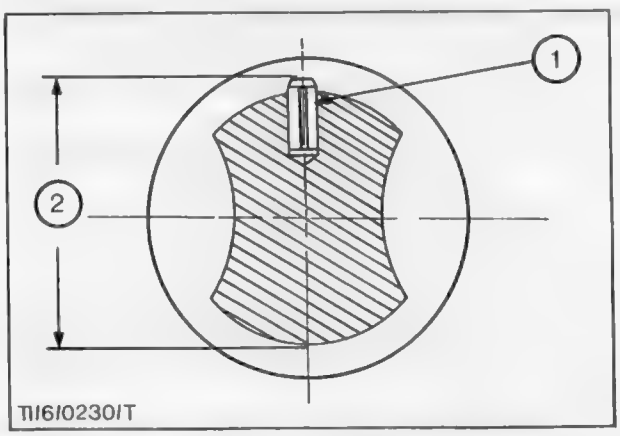


Fig. 29. 1. Roll pin
2. Assembled height (see specifications)

64. Protect the seal lip with a suitable assembly sleeve.

65. Position the pump body in the vertical plane and insert the assembled drive shaft.

66. Engage the drive shaft key with the vane pump impeller keyway, Fig. 30.

67. Prepare the cam roller ring. If despite all the precautions detailed in sub-operation 38, the relative roller positions are not known the height of the rollers assembled in the cam roller ring must be measured. The difference in assembled roller heights must not exceed 0,02 mm (0,0008 inches) when fitting rollers to the roller ring ensure the spring seat is positioned on the roller outer face, crown side towards the outer ring.

68. Fit the connecting shaft to the roller ring, position the cross bore vertically.

69. Carefully fit the cam roller ring to the pump body, ensure the connecting shaft points in the direction of the advance piston bore, Fig. 31.

70. Fit the cross piece and inner shim to the advance piston, retain in position with a suitable grease.

71. Fit the advance piston into the housing bore so that the compression spring recess is on the same side as the pump body return bore.

72. Engage the connecting shaft with the advance piston cross piece.

73. Fit the connecting shaft retaining pin, fit the spring clip.

74. Check the advance piston for freedom of movement.

75. Fit a new 'O' ring, fit and secure the timing device flat cover. Tighten the screws to specifications.

76. From the specification sheet determine the advance piston shim pack requirement.

77. Assemble the correct shim pack. Fit one shim to the advance piston, Fig. 32.

78. Fit the remaining shims to the cover recess.

79. Fit the compression spring.

80. Fit a new 'O' ring to the recess cover, fit and secure the cover. Tighten the screws to specifications.

    NOTE: At least one shim must be fitted each side of the advance piston compression spring.

81. Assemble the pressure control valve with two new 'O' rings.

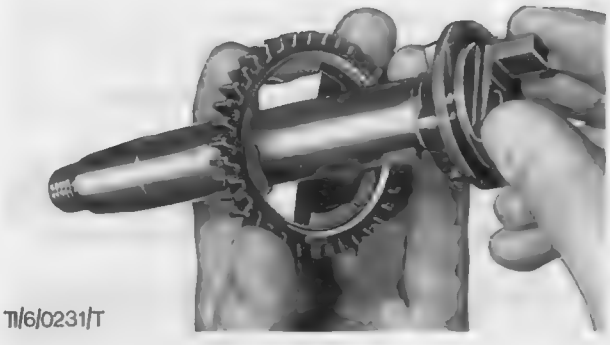


Fig. 30. Fit gear to shaft; recess to drive coupling

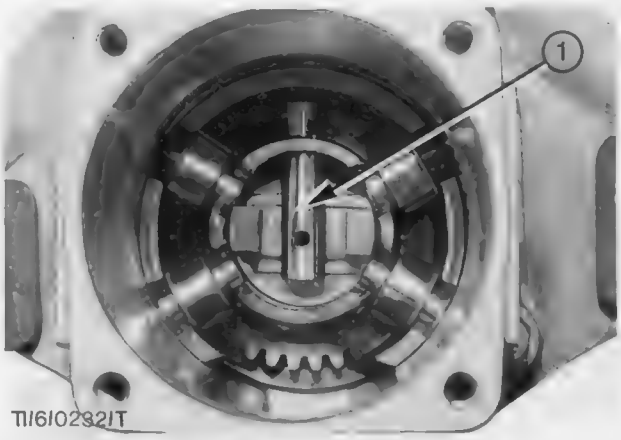


Fig. 31. Connecting shaft positioned towards advance piston

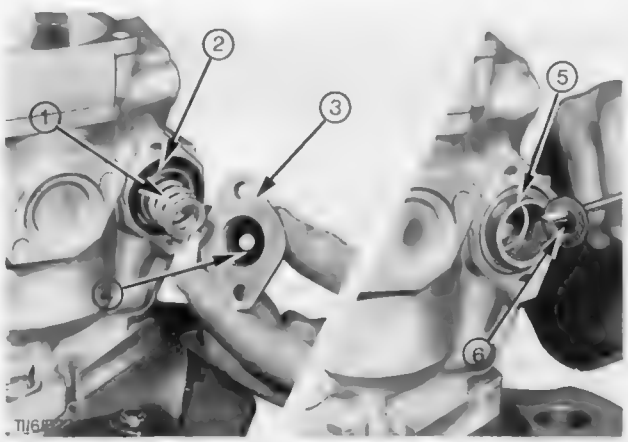


Fig. 32. Assemble advance piston

1. Compression spring
2. Advance piston
3. Recess cover
4. Recess cover shims
5. Advance piston
6. Advance piston shim

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82. Using Special Tool No. KDEP 1086 fit the pressure control valve to the pump body.

83. Fit the drive coupling into the cam roller ring, compression spring recess uppermost.

84. Fit the cam plate to the drive coupling.

NOTE: To ensure correct timing the cam plate drive pin must be aligned with the drive shaft key way. Incorrect alignment relative to the drive shaft will result in engine damage.

To determine the dimension 'KF' (plunger – spring stroke). The dimension 'KF' is the distance between the sealing surface on hydraulic head and the end face surface of the pump plunger.

85. Fit the base adaptor Special Tool No. KDEP 1032 to the dial indicator Special Tool No. 1 687 233 012, Fig. 33.

86. Using a suitable flat plate adjust the base adaptor to give a total plunger travel of 25 mm (indicated on the red hand).

87. Fit the spring guide pins to the hydraulic head, fit the upper spring plates to the pins, Fig. 34.

88. Fit the springs (no shims to be fitted) to the upper plate and pin assemblies.

89. Fit the thrust washer and shim to the pump plunger.

90. Fit the lower spring plate to the pump plunger.

91. Fit the plunger/lower spring plate assembly to the hydraulic head and assembled components.

92. Hold the hydraulic head in the horizontal position.

93. Push lightly against the plunger base, this pressure must be sufficient to hold the lower spring plate in contact with the compression springs. Under no circumstances must the springs be compressed.

94. Enter the dial indicator plunger into the hydraulic head via the screw plug aperture.

95. Compare the measured dimension (red figures on the dial indicator) with the normal value given in the specifications for 'KF', Fig. 35, equalise with shims fitted beneath the upper spring plates.

NOTE: If there is a choice between two different thicknesses of spacer, the thicker spacer is to be used. Do not fit two shims of the same dimension to the same guide pin.

Fig. 33. Dial indicator and base adaptor

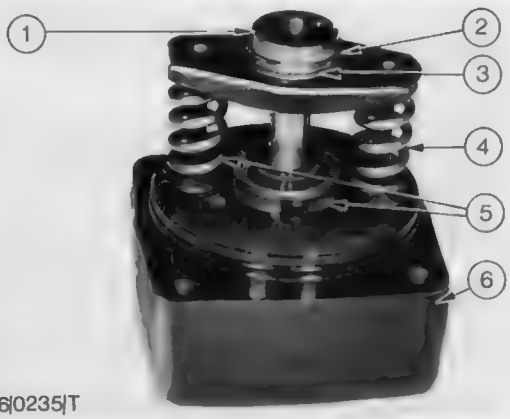

Fig. 34. Hydraulic head assembly
1. Pump plunger
2. Thrust washer
3. Shim
4. Spring
5. Spring and Governor control sleeve
6. Hydraulic head

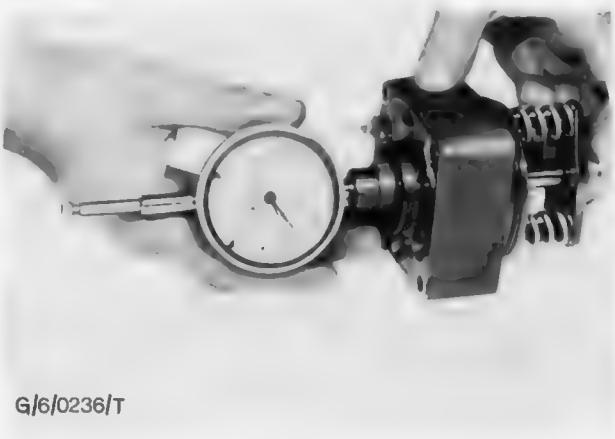

Fig. 35. Measure the dimension 'KF'

96. Disassemble the hydraulic head.

To adjust the relative position of the diameter pump plunger (dimension 'K').

NOTE: For this adjustment the drive coupling compression spring must be removed.

97. Place any dry shim in the plunger base.

    IMPORTANT: use no adhesive agent i.e. grease.

98. Fit the plunger and shim to the cam plate. Ensure the cam plate drive pin engages with the plunger base slot.

99. Carefully without disturbing the assembled parts, fit the hydraulic head over the pump plunger. Fit the hydraulic head retaining screws and tighten to specifications.

100. Rotate the drive shaft and position at any BDC.

101. The dimension 'K' is the distance between the sealing surface of the end face of the hydraulic head and the end face of the pump plunger.

102. Measurement of 'K' is carried out in the same way as was the dimension 'KF' using the same Special Tools i.e. KDEP 1032 and 1 687 233 012 set at the nominal 25 mm (1,0 in), Fig. 36.

103. Compare the measured dimension (red figures on the dial indicator) with the nominal value given the specifications for 'K', equalise with shims fitted beneath the plunger base.

104. If the measured dimension is greater than the specified nominal value of 'K' a thicker shim needs to be inserted, whilst if the measured dimension is less than the nominal value of 'K' a thinner shim is required.

105. Finally check the dimension 'K' to ensure correct shim has been fitted.

106. Refit the coupling compression spring between the drive coupling and the cam plate.

    NOTE: To ensure correct pump timing the cam plate drive pin must be aligned with the drive shaft keyway. Incorrect alignment relative to the drive shaft will result in engine damage.

107. Check the ball stud of the control lever assembly in the governor control sleeve hole for freedom of movement.

108. Fit the thrust washer and shim to the pump plunger.

109. Fit the lower spring plate to the pump plunger.

110. Fit the governor control sleeve to the pump plunger, ground collar face upwards, Fig. 37.

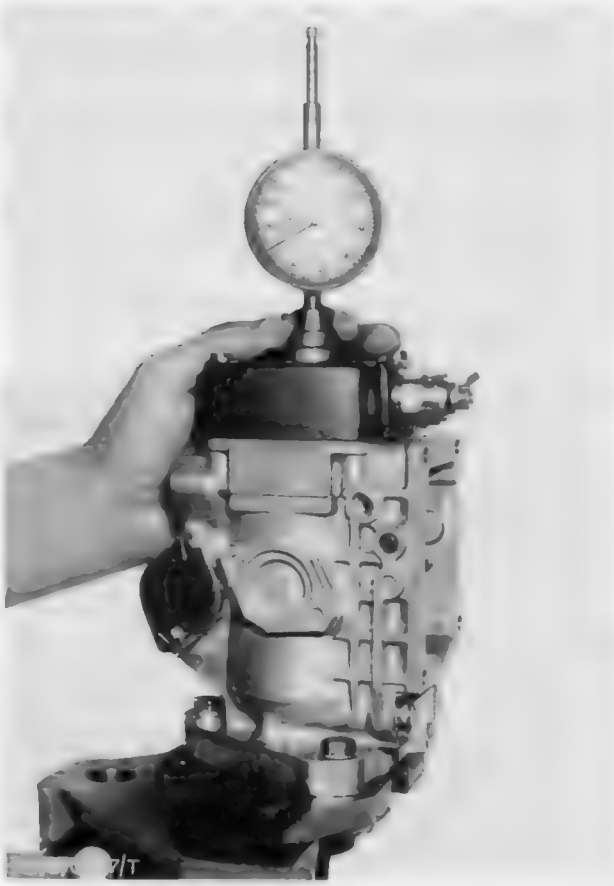

Fig. 36. Measure the dimension 'K'

Fig. 37. Fit the control sleeve ground face uppermost

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111. Fit the plunger assembly with the calculated shim into the cam plate. Ensure the cam plate drive pin engages with the plunger base slot.

112. Place the helical compression springs on the lower spring seats.

113. Fit the control lever assembly to the pump body, fit the pivot bolts and washers. Tighten the bolts to specification.

114. Engage the control lever ball with governor control sleeve, Fig. 38.

115. Fit the guide pins, shims and upper spring seats to the hydraulic head. A suitable grease will help retain the spring components.

116. Using a suitable grease fit the control lever springs to the hydraulic head.

117. Fit 'O' ring to the hydraulic head.

118. Push the assembled hydraulic head into the pump housing so that the compression springs are aligned with the control lever assembly, Fig. 39. Particular care should be taken to ensure the guide pins are located in the guide holes of the lower spring seat when the hydraulic head is introduced and tightened. Incorrect assembly may result in the breaking of the lower spring seat. In addition ensure the ball stud of the control lever assembly is correctly located in the governor control sleeve.

119. Fit the hydraulic head retaining screws tighten to specification.

120. Fit and securely tighten the fuel solenoid shut-off, if fitted.

121. Stick the governor shims and shim plate in the pump housing with a suitable grease.

122. Assemble the governor i.e. flyweight, shim ring, sliding sleeve and blanking plug assembly.

NOTE: The flyweights, if replaced must be renewed as a set of four.

123. Fit the governor assembly in the pump housing.

124. Fit a new 'O' ring to the governor shaft. Screw the shaft into the housing until the dimension 1,5 to 2,0 mm (0,059 to 0,079 inches) measured from the surface of the flange to the end of the governor shaft is attained, Fig. 40.

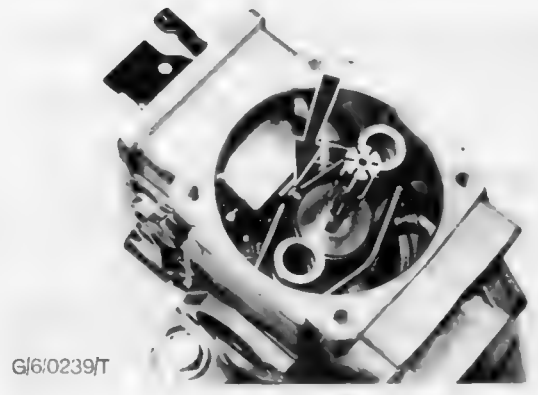

Fig. 38. Engage the control lever ball with the governor control sleeve

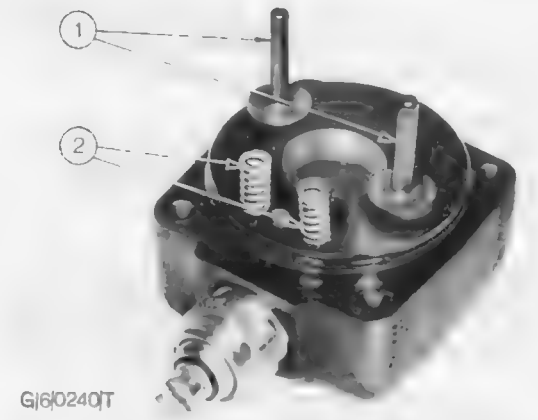

Fig. 39. 1. Spring guide pins 2. Compression springs

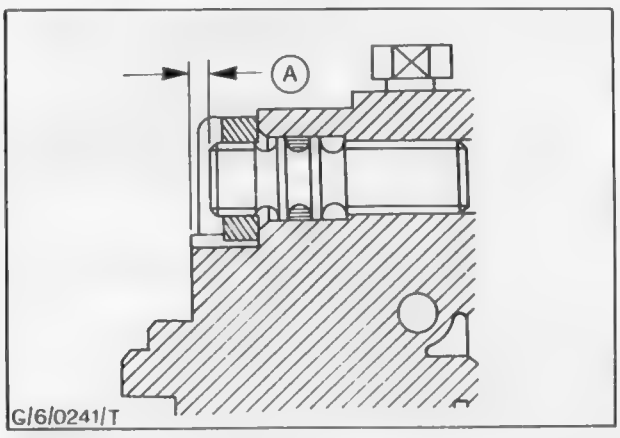

Fig. 40. Governor shaft dimension

125. Measure the axial play of the flyweight assembly with a feeler gauge, Fig. 41.

126. Adjust the axial play to specification by adjusting the shim pack.

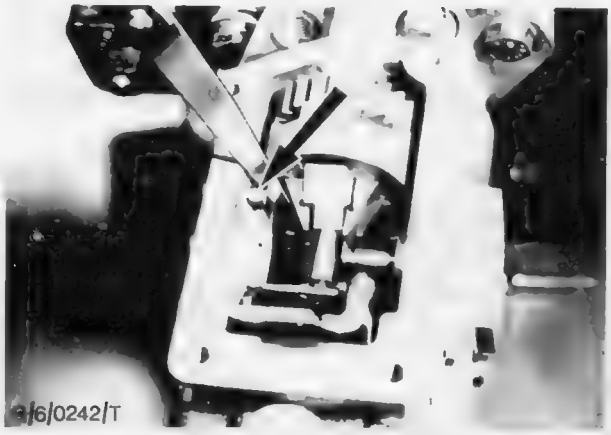

Fig. 41. Measure the flyweight axial play

127. Using Special Tool No. KDEP 1082 lock the governor shaft in position with the slotted round nut. Tighten to specifications, Fig. 42.

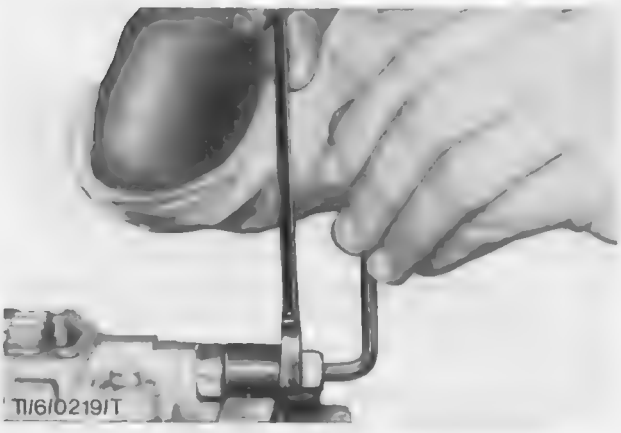

Fig. 42. Using Special Tool No. KDEP 1082 lock the governor shaft

To determine the dimension 'MS' (Starting Fuel).

128. Fit the register block Special Tool No. KDEP 1084 to the pump housing, machined surface towards the correction lever.

129. Push the tensioning lever against the pin stop.

130. Using feeler gauges measure the distance 'MS' i.e. the distance between the governor sliding sleeve plug and the starting lever which is up against the tensioning lever, compare the 'MS' value with the specications, Fig. 43.

131. The 'MS' dimension is corrected by removing the flyweight assembly. The sliding sleeve is then removed and the end plug driven from the sleeve with a suitable punch. A different end plug is then fitted with a longer or shorter nipple to obtain the specified 'MS' figure when assembled in the pump body.

Fig. 43. Measure the dimension 'MS'

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132. Remove the register block special tool KDEP 1084 from the pump housing.

133. Fit the accelerator interior linkage and spindle assembly to the housing cover.

134. Fit the return spring.

135. Fit the upper accelerator linkage to the spindle as previously marked.

136. Fit the spring/accelerator linkage retaining bracket, fit and tighten the retaining nut to specification.

NOTE: For testing purposes it is advantageous to leave the accelerator return spring unhooked from the accelerator linkage.

Install mechanical shut-off (if fitted)

137. Fit the washer to the mechanical shut-off inner linkage assembly.

138. Fit the shaft to the housing cover.

139. Fit the shim and seal.

140. Fit a spacer 27,7 mm (1,09 in) long between the inside edge of the housing cover and the interior shut-off lever.

141. Retain the shaft by holding the interior linkage against the spacer.

142. Fit the outer lever to the shaft so that the smallest possible gap exists between the shut-off lever and the housing cover.

143. Fit the lockwasher and nut, tighten the nut to specification.

144. Measure and note the outer lever to housing cover gap.

145. Insert a feeler guage of the previously noted dimension between the mechanical shut-off linkage and the housing cover, Fig. 44.

146. Adjust the threaded stop bolt to allow a horizontal stroke of 21,5 to 22,0 mm (0,846 to 0,866 in). Tighten the stop bolt locknut to specification, Fig. 45.

All models

147. Fit a new 'O' ring to the housing cover.

148. Hook the tension spring into the accelerator inner linkage so the opening in the spring is pointing downwards, Fig. 46.

149. Push the retaining pin with the helical compression springs through the hole in the tensioning lever and attach the tension spring.

NOTE: The retaining pin with helical compression springs are serviced as a unit.

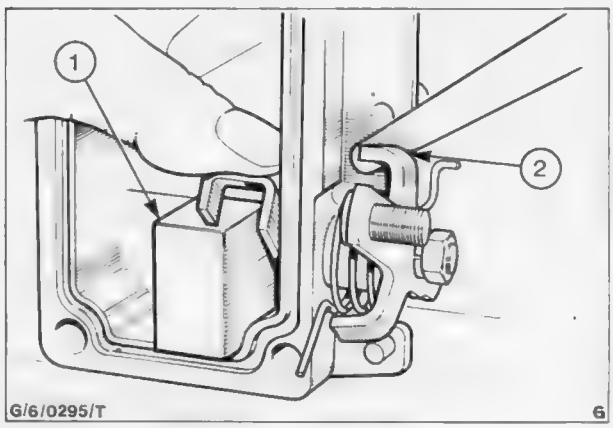

Fig. 44. Adjust Fuel Shut-Off
1. Spacer 2. Feeler gauge

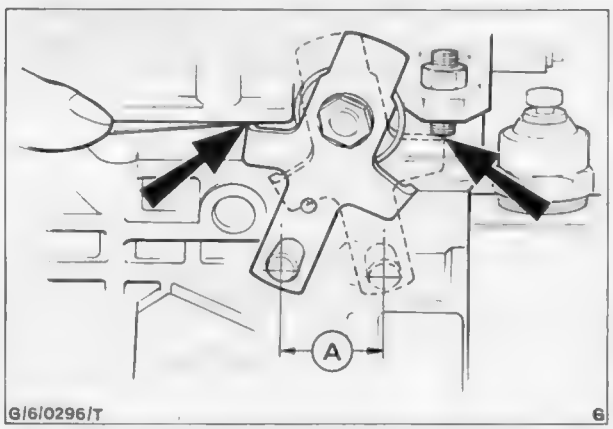

Fig. 45. Adjust Fuel Shut-Off Stroke between housing cover and adjustment bolt
A – Horizontal stroke

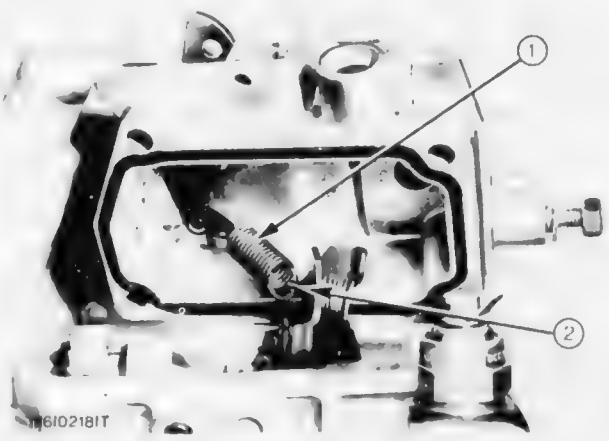

Fig. 46. Fit the tension spring:
1. Tension spring 2. Spring open end

150. Fit the housing cover, tighten the retaining screws to specification.
151. Fit new copper washers to the hydraulic head.
152. Assemble the valves i.e. shims, springs and two valve components, Fig. 47.
153. Fit the valve and valve holders in the correct positions i.e. A.B.C.D. tighten the valve holders to specifications.
154. Fit a new 'O' ring to the screw plug.
155. Using Special Tool No. KDEP 1080 fit and tighten the screw plug to specifications.

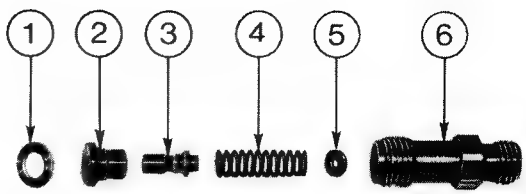

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Fig. 47. Valve Assembly
1. Washer
2. Valve body
3. Valve plunger
4. Spring
5. Shim
6. Valve holder

FUEL INJECTION PUMP

Type	Distributor
Rotation	Clockwise from drive end
Timing	TDC
Pumping Element (Plunger)	
Plunger diameter	10,00 mm (0,39 in)
Return Spring	
Rate	72,5 N/mm (7,4 kgf/mm) (408 lbf/in)
Strength	32,5 kgf at 25,5 mm (71,6 lbf at 1 in)
Number of springs	2
Spill Ports	
Number of spill ports	2
Length	2 mm (0,08 in)
Width	2 mm (0,08 in)
Depth	0,5 to 1,5 mm (0,02 to 0,06 in)
Offset axially	0,2 mm (0,08 in)
Prestroke (spill cut off dial indicator reading	0,3 mm (0,012 in)
Cam	
Total cam lift	2,2 mm (0,09 in)
Camlift at spill	0,3 mm (0,012 in)
Camlift at timing mark	1,14 mm (0,045 in)
Delivery Valves	
Unloading	35 mm^3 (1,38 in^3)
Spring rate	4,8 N/mm (0,5 kgf/mm) (27 lbf/in)
Strength	4,25 kgf at 15,7 mm (9,3 lbf at 0,6 in)
Transfer Pump/Flow Control Valve	
Number of vanes	4
Number of orifices	2
Orifice diameter	2 mm (0,078 in)
Valve spring rate	15,3 N/mm (1,6 kgf/mm) (27 lbf/in)
Spring strength	0,77 kgf at 14,5 mm (1,7 lbf at 0,57 in)
Governor	
Type	Mechanical
Number of weights	4
Weight	10 grams (0,14 oz)
Spring rate	3 N/mm (0,3 kgf/mm) (16,9 lbf/in)
Spring strength	2,57 kgf at 39,3 mm (5,7 lbf at 1,55 in)
Gear Train	
Camshaft gear	37 teeth
Governor cage	23 teeth
Advance Unit	
Spring rate	31 N/mm (3,2 kgf/mm) (174 lbf/in)
Strength	2,5 kgf at 34,6 mm (5,5 lbf at 1,36 in)
Idle Spring	
Rate	0,45 N/mm (0,05 kgf/mm) (2,5 lbf/in)
Free length	8,65 mm (0,34 in)
Wire diameter	0,5 mm (0,02 in)
Idle Assist Spring	
Spring rate	0,8 N/mm (0,08 kgf/mm) (4,5 lbf/in)
Free length	8,3 mm (0,33 in)
Wire diameter	0,7 mm (0,03 in)
Roller Ring	
Height	31,75 to 31,8 mm (1,250 to 1,252 in)

Overhaul Specifications

Timing Device (Advance Piston)		**Part number (Bosch)**
Nominal dimension	4,2 mm Max	
Shim sizes (Piston)	0,6 mm	1 460 100 612
(cover)	0,6 mm	1 460 100 612
	0,7 mm	1 460 100 613
	0,9 mm	1 460 100 614
	1,0 mm	1 460 100 615
	1,2 mm	1 460 100 616

Note: Piston shim 1 1460 100 612 must be fitted with at least one cover shim.

Dimension MS		**Part number (Bosch)**
Nominal dimension	2,1±0,1 mm	
Nipple sizes	7,2 mm	1 463 120 338
	7,4 mm	1 463 120 339
	7,6 mm	1 463 120 340
	7,8 mm	1 463 120 341
	8,0 mm	1 463 120 342
	8,2 mm	1 463 120 343
	8,4 mm	1 463 120 344
	8,6 mm	1 463 120 345
	8,8 mm	1 463 120 346
	9,0 mm	1 463 120 347
	9,2 mm	1 463 120 348
	9,4 mm	1 463 120 349
	9,6 mm	1 463 120 350
	9,8 mm	1 463 120 351
	10,0 mm	1 463 120 352
	10,2 mm	1 463 120 353
	10,4 mm	1 463 120 354
	10,6 mm	1 463 120 355

Dimension K		**Part number (Bosch)**
Nominal dimension	Not measured, hydraulic test.	
Shim sizes	1,90 mm	1 460 100 116
	1,92 mm	1 460 100 117
	1,94 mm	1 460 100 118
	↕ etc	↕ etc
	2,86 mm	1 460 100 164
	2,88 mm	1 460 100 165
	2,90 mm	1 460 100 166

Dimension KF		**Part number (Bosch)**
Nominal dimension	5,8±0,1 mm	
Shim sizes	0,5 mm	1 460 100 312
	0,8 mm	1 460 100 313
	1,0 mm	1 460 100 314
	1,2 mm	1 460 100 315
	1,5 mm	1 460 100 316
	1,8 mm	1 460 100 317
	2,0 mm	1 460 100 318

Governor Weight Axial Play		**Part number (Bosch)**
Nominal dimension	0,15 to 0,35 mm	
Shim sizes	1,05 mm	1 461 030 302
	1,10 mm	1 461 030 303

Governor Weight Axial Play (cont'd)		Part number (Bosch)
	1,25 mm	1 461 030 304
	1,45 mm	1 461 030 306
	1,60 mm	1 461 030 305
	1,65 mm	1 461 030 308
	1,80 mm	1 461 030 307
	1,85 mm	1 461 030 310
	2,00 mm	1 461 030 309

Full Load Adjustment Spacer		Part number (Bosch)
	2,0 mm	1 460 200 301
	2,2 mm	1 460 200 302
	2,4 mm	1 460 200 303
	2,6 mm	1 460 200 304
	2,8 mm	1 460 200 305
	3,0 mm	1 460 200 306
	3,2 mm	1 460 200 307
	3,4 mm	1 460 200 308
	3,6 mm	1 460 200 309
	3,8 mm	1 460 200 310

Lower Spring Plate Shim/washer		Part number (Bosch)
washer	one size	1 460 101 018
Shim	one size	1 460 101 022
Roll pin to drive shaft assembled height	37,3 to 37,9 mm (1,46 to 1,49 in)	

Calibration Specifications

Pre-adjust Full Load Delivery

Speed rpm 1750	Fuel delivery (cc/200 shots average of all lines)	
	Hartridge 1100	Bosch Machines
	7,5 ± 0,1 cc	8,0 ± 0,1 cc

Maximum line to line spread 0,8 cc/200 shots.

Adjust the Timing Device Travel and the Supply Pump Pressure

Speed rpm	Cam box pressure (KN/m^2)	Advance unit piston travel (mm)
1600	595 ± 50	3,8 to 4,8

Figures apply to both Hartridge 1100 and Bosch test machine.

Adjust Low Idle Setting and Measure Excess Fuel for Starting

Test	Speed rpm	Speed lever position	Delivery cc/200 shots average of all lines		Maximum line to line spread cc/200 Shots
			Hartridge 1100	Bosch test machine	
Excess fuel	100	Maximum	13 to 20	13 to 20	2
Excess fuel	215	Maximum	13 to 20	13 to 20	2
Excess fuel	285	Maximum	Less than 13	Less than 13	2
Idle	300	Minimum	2,8 to 3,6	3,1 to 3,9	1

These tests to be carried out together to ensure excess fuel delivery does not affect idle.

Adjust Maximum Speed Setting

Speed rpm	Fuel delivery cc/200 shots average of all times	
	Hartridge 1100 machine	Bosch machines
2000	2,0 ± 0,2	2,6 ± 0,2

Note: Fuel deliveries shown are averages of all lines over 200 shots. Maximum line to line spread 0,8 cc/200 shots.

Overflow Quantity [This test to be carried out with a feed pressure of 0,242 Bar (0,245 kgf/cm²) (3,5 lb/in²)]

Speed rpm	Overflow Quantity litre/hour
500	18
1800	28

Fuel Delivery and Breakaway Characteristics

Speed rpm	Fuel delivery (cc/200 shots)	
	Hartridge 1100 machine	Bosch machine
1750	7,5 ± 0,4	8,0 ± 0,4
1250	As found at 1750 +0,2 to +0,7	As found at 1750 +0,7 to +1,2
800	As found at 1750 −0,9 to −0,3	As found at 1750 +0,2 to +0,7

Note: Fuel deliveries shown are averages of all lines over 200 shots. Maximum line to line spread 0,8 cc/200 shots at stated speeds.

Accelerator Lever Adjustment Dimensions

Dimension A (lever position at idle)	10,2 ± 2,5 mm (0,40 ± 0,1 in)
Dimension B (lever to speed adjustment screw clearance)	10,3 ± 1,6 mm (0,41 ± 0,06 in)

Stop Control (Electric/Mechanical)

Fuel delivery @ 100 rpm	6,5 cc per 200 shots minimum (average of all lines)
Fuel delivery @ 1800 rpm	7,0 cc per 200 shots minimum (average of all lines)

Injector Specification

Nozzle type	DNOSD1930
Nozzle part No. (Bosch)	0 434 250 092
Nozzle opening pressure	145–153 Atmospheres
Nozzle rate	High flow
Injector part No. (Bosch)	0 423 287 049
Injector holder type	KB375A590/A
Injector holder part No. (Bosch)	0 431 201 [illegible]36
Spring part No. (Bosch)	2 434 619 009

TIGHTENING TORQUES	Nm	kgf/m	lbf/ft
Control valve	8 to 9	0,8 to 0,9	5,9 to 6,6
Throttle stop screw locknut	5 to 6	0,5 to 0,6	3,7 to 4,4
Timing device cover retaining screws	6 to 8	0,6 to 0,8	4,4 to 5,9
Drive shaft nut	60	6,2	45
Control lever pivot bolt	10 to 13	1,0 to 1,3	7,4 to 9,6
Vane pump retaining screws	2 to 3	0,21 to 0,3	1,5 to 2,2
Hydraulic head retaining screw	11 to 13	1,1 to 1,3	8,1 to 9,6
Governor shaft lockring	25 to 30	2,5 to 3,1	18,4 to 22,1
Accelerator linkage retaining nut	5 to 10	0,5 to 1,0	3,7 to 7,4
Housing cover retaining screw	6 to 8	0,6 to 0,8	4,4 to 5,9
Screw plug	60 to 80	6,1 to 8,1	44,2 to 58,9
Solenoid valve	40 to 45	4,1 to 4,6	29,4 to 33,2
Bleed screws	8 to 10	0,8 to 1,0	5,9 to 7,4
Speed adjustment locknut	7 to 9	0,7 to 0,9	5,2 to 6,6
Inlet and outlet unions	20 to 25	2,0 to 2,5	14,7 to 18,4
Fuel filter bleed screw	8 to 10	0,8 to 1,0	5,2 to 6,6
Pump flange to front cover nuts and bolts	20,3 to 27	2,0 to 2,8	15 to 20
Injector delivery pipes	17,2 to 20,3	1,8 to 2,0	13 to 15
Valve holder	35 to 45	3,6 to 4,6	25,8 to 33,2
Pump drive gear retaining bolts	14,8 to 20,0	1,5 to 2,1	11 to 15
Timing belt cover screws	4,9 to 8,8	0,5 to 0,9	3,6 to 6,5
Alternator mounting bolts	9,5 to 14,9	1,0 to 1,5	7 to 11
Water pump pulley retaining bolts	19,0 to 24,3	1,9 to 2,5	14 to 18